SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

OCTOBER 1900.

GENERAL PHYSICS.

1977. *Maximum Density of Aqueous Solutions.* **L. C. de Coppet.** (Comptes Rendus, 131. p. 178, July 16, 1900.)—The lowering of the temperature of maximum density of water by the addition of 1 gramme molecule of salt dissolved in 1,000 gms. of water is found to be—

For ammonium chloride	between	7·07	and	7·26
„ lithium bromide	„	7·01	„	7·08
„ lithium iodide	„	8·17	„	8·45

R. E. B.

1978. *Desiccation of Hydrogen by Liquid Air.* **Rayleigh.** (Roy. Soc., Proc. 66. p. 334, June 9, 1900.)—No appreciable difference exists between the values of the density of hydrogen obtained when the gas is dried (1) by means of phosphoric anhydride and (2) by liquid air. T. H. P.

1979. *Double Films.* **R. Malagoli.** (N. Cimento, 11. pp. 351–353, May, 1900.)—The object of the author is the production of durable films on skeleton figures. A solution is made by dissolving 40 grammes of gelatine and 10 grammes of soap in 500 grammes of water. During the preparation care should be taken that the temperature does not exceed 80° C. The solution should be filtered if necessary. It is best used at a temperature of from 30° to 33° C. in a room whose temperature is not above 20° C. The films are obtained by dipping the skeletons into the solutions. Twelve hours are required to dry them. They are not thin enough to show interference colours. They may be strengthened with thin collodion, or by spraying on them copal varnish diluted with turpentine. A. G.

1980. *Gasometer.* **J. Riban.** (Journ. de Physique, 9. pp. 343–347, June, 1900.)—The ordinary portable laboratory gasometer, known as Mitscherlich's, does not give a constant flow of gas, as the height of the column of liquid representing the pressure on the gas continually decreases as the flow proceeds. In a new arrangement devised by the author this inconvenience is done away with, and, further, the upper reservoir containing the water is arranged to slide up and down on three vertical supports so that its height, and hence the pressure on the gas in the gas-holder, can be varied at will; connection is made between the two vessels by means of flexible tubing. By supplying the upper reservoir with an overflow pipe it is possible to leave the apparatus at work if necessary, all night, the only change in the pressure being that due to the change of temperature of the surrounding air. The gasometer, which is fully described and illustrated in the original paper, is readily freed from all traces of air or other gas previously present and also avoids all loss of the gas employed. T. H. P.

1981. *Expansion of Cast Silica.* **H. le Chatelier.** (Comptes Rendus, 130. pp. 1703–1705, June 18, 1900.)—An expansion coefficient of 0·0000007 between 0° and 1,000° is found for silica cast in an electric furnace. The method of measurement is that of finding the difference of lengthening of two prisms, one of which is a standardised porcelain prism. Cast silica should be capable of undergoing sudden changes of temperature without rupturing. Addition of aluminium lowers the melting-point of the silica but increases the expansion. A substance with the composition $10SiO_2 . Al_2O_3 . 2Li_2O$ expands slightly more than cast silica and melts at about 1,200°. G. E. A.

1982. *Rapid Cooling of Cast Silica.* **Dufour.** (Comptes Rendus, 130. pp. 1754–1755, June 25, 1900.)—The author had confirmed the property of cast silica of resisting sudden changes of temperature, but without knowing the explanation. Tubes of cast quartz may be heated to any extent and then plunged into cold water without showing any trace of rupture. The method of making the tubes is described. [*Cf.* previous Abstract.] G. E. A.

1983. *Propagation of Explosive Waves.* **H. le Chatelier.** (Comptes Rendus, 130. pp. 1755–1758, June 25, 1900.)—The author employs the photographic method devised by him in conjunction with Berthelot to study the propagation of the explosive wave in mixtures of acetylene with oxygen or the oxides of nitrogen, and of carbon monoxide and oxygen in the proportion CO : O. In mixtures of acetylene and oxygen ignited by means of an electric spark, the speed of propagation of the flame immediately assumes a value of several hundreds of metres per second and rapidly increases to beyond 1,000. Shortly after the appearance of the flame the explosive wave, with a greater and uniform velocity, is suddenly formed. The following table contains the distances travelled by the flame before the explosive wave comes into existence, the various mixtures being exploded in a tube 10 mm. in diameter :—

$2C_2H_2 + O_2$	1 metre	$C_2H_2 + 2NO$	0·20 metre
$C_2H_2 + O_2$	0·05 „	$C_2H_2 + 6NO$	0·50 „
$C_2H_2 + 6O_2$	0·15 „	$C_2H_2 + 2N_2O$	1·00 „
$C_2H_2 + 10O_2$	0·80 „	$C_2H_2 + 6N_2O$	0·10 „

For the mixture $C_2H_2 + O_2$ the velocity of the explosive wave has its greatest value, 2,920 metres per second, the number for $C_2H_2 + 10O_2$ being 1,850. The other gaseous mixtures give similar numbers. In the case of mixtures of carbon monoxide and oxygen, the explosive wave is not formed spontaneously but can be produced by the detonation of a certain small quantity of fulminate of mercury. T. H. P.

1984. *Propagation of Waves of Condensation in Hot Gases.* **H. le Chatelier.** (Comptes Rendus, 131. pp. 30–33, July 2, 1900.)—In studying the propagation of waves of condensation in the cases of hot gases produced by the combustion of explosive mixtures the author has employed a photographic process. He finds that the thickness of the wave, *i.e.*, of the zone of variable state, is in all cases very small. For slightly condensed waves the thickness is considerably less than 1 cm., and it only takes $\frac{1}{1000}$ of a second for any point in the gas to pass from one extreme state to the opposite one. For more condensed waves the thickness seems to attain 1 cm., but the author considers that in this case irradiation on the photographic plate may have increased the apparent thickness of the wave.

The explosive wave produced by the ignition of a mixture of $C_2H_2 + O_2$ was found to travel with a velocity of 2,990 mm., the wave produced by the ignition of $\frac{1}{10}$ gr. of fulminate of mercury travelled with a velocity of 2,250 mm. in the same gas, while that produced by 0·75 gr. of fulminate travelled with a velocity 2,600 mm.—a velocity which approaches, but does not equal, that of the explosive wave.

Similar experiments were made with a mixture of $CO + O_2$.

The tubes in which the gases were contained were 5 mm. in diameter and 1 metre long.

When the waves cross in the tube they suffer a diminution in velocity and also after reflection from the ends. For example—

Initial velocity	2,300
After reflection	1,350
After first crossing	1,080
After second crossing	980

W. C. O.

1985. *Approximately Simple Waves.* **Rayleigh.** (Phil. Mag. 50. pp. 135–139, July, 1900.)—The phrase, "absolutely simple waves," standing for those which do not admit of variations of phase or amplitude, *approximately* simple waves are here "defined as waves which *for a considerable succession* deviate but little from a simple train. Under this definition large changes of amplitude and frequency would not be excluded, provided only that they entered slowly enough." After touching briefly upon the case of "beats," the paper deals specially with the contrasted case, hitherto neglected, in which the amplitude remains constant, and the sole variation is one of phase. It is then shown that the vibration

$$\cos(pt - a \sin qt)$$

can be analysed into a series of cosines of pt, $(p \pm q)t$, $(p \pm 2q)t$, $(p \pm 3q)t$, &c., the coefficients being Bessel's functions of a, the maximum disturbance of phase.
E. H. B.

1986. *Temperature in Mercury Mine of Idria.* **T. Scheimpflug** and **M. Holler.** (Akad. Wiss. Wien, Sitzb. 108. pp. 950–975, 1899.)—Painstaking observations have been made of the temperature in various parts of the mine. In a certain region the temperature was found to be a maximum, about 27° C. Thus from that spot the temperature diminishes in all directions, even downwards. Some excellent diagrams illustrate the results at a glance. A. G.

1987. *Seismograph with Vertical Pendulum.* **C. Viola.** (Accad. Lincei, Atti, 9. pp. 817–821, May 20, 1900.)—The author describes the working of a seismograph with vertical pendulum, and how it is supposed to trace on a horizontal paper any motion that may be communicated to the paper by the earth, the amplitude of vibrations being magnified by levers. The pendulum is about 10 metres in length, and has a mass of 500 kgs.

The author states that the modern perfected instrument ought to be able to give the instant that the first shock occurs; but he undertakes to prove that all other motions after the first vibration are illusory. In the mathematical work which follows he proves that certain important quantities are functions of the inertia of the building or support, and are therefore unobtainable. Seismographs with double pendulums, favoured by Milne, are also criticised. A. G.

1988. *Escape of Gases from Planetary Atmospheres.* **G. Johnstone Stoney.** (Astrophys. Journ. 11. pp. 257–258, May, and 357–372, June, 1900.)—The present paper is an answer to a criticism of the work of Stoney by S. R. Cook. Stoney draws attention to the statement that Maxwell's laws cannot be applied to gases under the conditions existing at the outer limits of a planet's atmosphere, but that the numbers determined by Cook will be useful as indicating the *minimum* rate of escape for the various gases.

The paper is divided into three parts, describing respectively: (1) Molecular movements in the lower strata of the atmosphere. (2) Molecular movements in the upper strata of the atmosphere. (3) Behaviour of helium, &c., in the earth's atmosphere. The conclusions from section (3) are as follows: (*a*) Argon is not able to escape from the earth. (*b*) Helium is escaping from the earth, and therefore (*c*) Water can probably escape from the planet *Mars;* thus the polar caps of that body may be due to solid carbon dioxide. [See further Abstracts Nos. 1025 (1898), and 805 (1900).] C. P. B.

REFERENCE.

1989. *Experimental Research.* **Elihu Thomson.** (Amer. Assoc., Proc. 48. 75–90, 1899.)—Presidential address to Section B at the 1899 meeting of the American Association for the Advancement of Science.

LIGHT.

1990. *Transparency and Opacity.* **Rayleigh.** (Roy. Inst., Proc. pp. 1–4, 1899.)—One kind of opacity is due to absorption; but the lecture dealt rather with that deficiency of transparency which depends upon irregular reflections and refractions. One of the best examples is that met with in Christiansen's experiment. Powdered glass, all from one piece and free from dirt, is placed in a bottle with parallel flat sides. In this state it is quite opaque; but if the interstices between the fragments are filled up with a liquid mixture of bisulphide of carbon and benzole, carefully adjusted so as to be of equal refractivity with the glass, the mass becomes optically homogeneous, and therefore transparent. In consequence, however, of the different dispersive powers of the two substances, the adjustment is good for one part only of the spectrum, other parts being scattered in transmission much as if no liquid were employed, though, of course, in a less degree. The consequence is that a small source of light, backed preferably by a dark ground, is seen in its natural outlines but strongly coloured. The colour depends upon the precise composition of the liquid, and further varies with the temperature, a few degrees of warmth sufficing to cause a transition from red through yellow to green.

The lecturer discussed various arrangements of solid and liquid bodies, such as solid prisms, discs, and spheres immersed in a liquid. He finally discussed the failure of transparency which arises from the presence of particles small compared to the wave-length of light. The tints of the setting sun were illustrated by passing the light from the electric lamp through a liquid in which a precipitate of sulphur was slowly forming. The lecturer gave reasons for his opinion that the blue of the sky is not wholly, or even principally, due to particles of foreign matter. The molecules of air themselves are competent to disperse a light not greatly inferior in brightness to that which we receive from the sky. E. E. F.

1991. *Phototropy.* **J. Marckwald.** (Phys. Zeitschr. 1. pp. 147–148, 1899. Paper read before the Naturforscherversammlung at Munich.)—The author gives the name *phototropy* to cases of change produced by the action of light which is not permanent, but in which the removal of the active light rays results in the return of the substances acted upon in a longer or shorter interval of time to their original condition. A new example of this action is recorded in which the salt of an organic base named from its constitution "Chino-chinolin," exhibits the following peculiarity: If its yellow crystals are freed from water of crystallisation at 100° they become green under the action of light, but if placed in the dark return to their original yellow colour. It is the rays of short wave-length, especially the violet, which have the power of producing this change, and the rapidity of the change depends on the intensity of the light. Direct sunlight causes the change in a few seconds, diffuse daylight in some minutes. The rate of change back again to the first colour depends on temperature. A case similar to this is also described. J. J. S.

1992. *Electromagnetic Rotation of the Plane of Polarisation by Solutions of Salts and Acids.* **J. Forchheimer.** (Zeitschr. Phys. Chem. 34. pp. 20–30, July 3, 1900.)—The author gives the results of experiments on a number of salts and acids carried out to test the accuracy of Perkin's view that with regard to the electromagnetic rotation of the plane of polarisation, the behaviour of salts is analogous to that of the corresponding acids. For the sulphates examined the results are given in the following table, in which *n* represents the normality of the solution and *m* the corresponding molecular rotation.

Ammonium sulphate.		Lithium sulphate.		Sodium sulphate.		Magnesium sulphate.		Sulphuric acid.	
n	*m*	*n*	*m*	*n*	*m*	*n*	*m*	*n*	*m*
3·75	4·98	2·60	2·38	0·97	2·985	2·73	2·03	11·58	2·072
2·964	4·95	1·96	2·80	0·48	2·955	1·86	2·02	9·01	2·072
1·978	4·87	1·708	2·64			0·934	2·04	6·95	1·991
0·876	4·95	1·320	2·67					4·77	1·960
0·492	5·01	0·747	3·11					3·008	2·030
								1·002	2·196

It will be seen from these values that solutions of the sulphates of ammonium, sodium, and magnesium resemble sulphuric acid in that the molecular rotation is independent of the concentration of the solution; in the case of lithium sulphate, however, the molecular rotation shows a considerable increase as the dilution becomes greater. For hydrochloric acid and some haloid salts the results are as follows:—

Hydrochloric acid.		Lithium chloride.		Cadmium bromide.		Cadmium iodide.	
n	*m*	*n*	*m*	*n*	*m*	*n*	*m*
8·42	4·476	10·35	4·506	2·774	20·18	1·924	43·86
5·784	4·559	7·17	4·732	1·997	20·07	0·951	42·70
3·77	4·757	5·57	4·767	0·973	19·95	0·447	42·54
2·031	4·856	2·98	4·983	0·5138	20·17	0·211	42·37
1·588	4·931	1·06	4·892				
1·138	4·831						
0·523	4·746						

Here again, in the cases of hydrochloric acid, cadmium bromide, and iodide, the molecular rotation does not vary with the concentration, whilst with lithium chloride the rotation increases with the dilution; this dependency of the molecular magnetic rotation on the concentration of the solution seems to be a special property of lithium salts. The numbers obtained confirm the observation of Jahn that the molecular rotations of cadmium bromide and iodide are respectively about twice and four times as great as that of the chloride, the value for which is 11·24. T. H. P.

1993. *Ultra-violet Spark Spectra.* **F. Exner** and **E. Haschek.** (Akad. Wiss. Wien, Sitzb. 108. pp. 825–859, 1071–1121, 1123–1151, and 1252–1266, 1899.)—*Niobium.* The commercial powder (Merck) contains Ca, Ba, Sr, Si, Ta, Be, and Fe. The spectrum of the metal has been hitherto practically unknown, but by the method of fractionation and exclusion, applied to strong and weak lines alike, the authors have been able to tabulate in this paper 1,804 ultra-violet lines, nearly all occurring in the solar spectrum.

Thorium. The strong lines of thorium appear in the solar spectrum as weak lines. The purity of the element cannot be made certain, and the arc-spectrum is as yet unknown. The number of established lines, between 8,900 and 4,700 λ reaches 2,070 (Lockyer, Phil. Trans., 1881; Lohse, Berl. Akad., 1897). The authors tabulate 688 in the ultra-violet, and believe there is no doubt that the number of lines in elements generally is a function of the atomic weights.

The spectra of silicon, beryllium, thallium, indium, cerium, lanthanum, neodymium, praseodymium, germanium, and gallium have been further studied (pp. 1071–1121).

The spectra of yttrium, erbium, and ytterbium have been mapped (pp. 1123–1151).

The following elements have been examined both in the visible and ultra-violet part of the spectra: Didymium, neodymium, praseodymium, erbium, yttrium, cerium, lanthanum, ytterbium, scandium, gadolinium, samarium (pp. 1252–1266).

[See further Abstracts Nos. 365 and 488 (1898).] S. R.

1994. *Absorption Spectra of Liquids in the Infra-Red.* **L. Puccianti.** (N. Cimento, 11. pp. 241–278, April, 1900.)—The author gives the results of measurements of the infra-red absorption bands of a number of liquid carbon compounds. The source of the rays used is a small incandescent electric lamp, the spectrometer prism being of quartz, and the intensity of the rays is measured by means of a modified form of Fox Nichols' torsion-radiometer. The compounds examined are: Benzene, toluene, ortho-, meta- and para-xylene, ethylbenzene, methyl iodide, ethyl iodide, ether, alcohol, methyl alcohol, pyridine, allyl alcohol, carbon bisulphide and carbon tetrachloride. The absorption curves show that all liquid compounds, the molecules of which contain carbon directly combined with hydrogen, present a maximum of absorption for the wave-length 1·71 μ. Further all the benzene derivatives examined have two other maxima in common, the wave-lengths being about 2·18 and 2·49 μ; these are probably due to the hexagonal structure of the molecule. The three isomeric xylenes exhibit absorptions almost, but not completely, identical; the curves for the three alcohols are also very similar. [See also Abstract No. 1646 (1900).] T. H. P.

1995. *Becquerel Rays.* **J. Elster.** (Deutsch. Phys. Gesell., Verh. 2. 1. pp. 5–8, 1900.)—Magnetic deviation of polonium rays is produced in a vacuum, and seems to be more than the deviation undergone by radium rays under the same conditions. Radium preparations contain an active volatile constituent. The effect of heating active barium bromide for twenty-four hours in a vacuum in a hard glass tube is to cause a temporary weakening of its activity which is almost quite recovered in a few days. If a trace of some radio-active substance is vaporised on a platinum wire in a bunsen flame the surrounding air becomes more capable of dissipating an electric charge.

G. E. A.

1996. *Radiation of a Black Body.* **M. Thiesen.** (Deutsch. Phys. Gesell., Verh. 2. 5. pp. 65–70, 1900.)—By Wien's law, the radiant energy of an absolutely black body at an absolute temperature T may be expressed in terms of T and the wave-length λ as follows:—

$$E = T^5 \phi\,[\lambda T] \qquad (1)$$

where ϕ is a function hitherto unknown. The radiation is perfectly known for all wave-lengths if the temperature is given, or for all temperatures when the wave-length is given. The law further indicates the existence of two natural constants which only depend upon the unit of temperature and the three mechanical units. In conjunction, therefore, with the velocity of light and the gravitational constant we obtain a natural measure for the temperature which is independent of any particular body. The author gives a new and more satisfactory deduction of the above law (1). As regards the distribution of energy in the spectrum, that is governed by the formula

$$\phi_{(x)} = \phi_m \left(\frac{x_m}{x} e^{1 - \frac{x_m}{x}} \right)^a \qquad (2)$$

$$5 > a > 2$$

where ϕ_m and x_m are the two natural constants, and ϕ_m is the maximum attained when x is a maximum. Paschen found experimentally $a > 5$. The author finds a value $a = 4{\cdot}5$, and shows that the formula (2) then agrees with the results of Wien, Planck, Rubens, Lummer, and Pringsheim.

E. E. F.

1997. *Magnetic Deflection of Becquerel Rays.* **H. Rubens and E. Aschkinass.** (Deutsch. Phys. Gesell., Verh. 2. 2. pp. 13–15, 1900.)—The magnetic deflection of Becquerel rays has been demonstrated by Giesel [see Abstract No. 61 (1900)], and by St. Meyer and v. Schweidler, but in their experiments it was very difficult to follow clearly the course of the rays. But Elster and Geitel have shown [see Abstract No. 60 (1900)], that Becquerel rays can be detected by their effect on a spark-gap. The authors have adopted the following arrangement: The electrodes used are of unequal curvature, the positive one being a rod with rounded end and the negative one a sphere of about 25 mm. diameter. They are connected to an induction machine and adjusted at such a distance apart as just to allow of a steady stream of sparks. On bringing near a radio-active substance the sparks disappear and are replaced by a glow-discharge. The drawback of the method is that the surface of the electrodes is soon affected, and they have to be frequently polished in order to keep them in good order. The drawback can be avoided by placing in parallel with this spark-gap A another B, in which the electrodes are balls of equal size. The electrodes A are drawn so far apart that sparking ceases; the electrodes B are then brought near enough together to allow of steady sparking. If now active rays fall upon A the sparking at B ceases, whereas similar rays falling upon B produce no noticeable effect. In order to get an approximately parallel bundle of rays, the radium-preparation was placed inside a thick lead tube. Experiments with an electromagnet showed that the rays were deflected in the direction in which negatively-charged particles would move in the magnetic field.

D. E. J.

1998. *Radium-barium Salts.* **F. Giesel.** (Deutsch. Phys. Gesell., Verh. 2. 1. pp. 9–10, 1900.)—Transmission of radio-activity is observed when a small quantity of an ordinary bismuth chloride solution is added to a solution of strongly active barium chloride, and the bismuth precipitated by H_2S. A screen shows that the bismuth chloride has become active. The brown-red colour shown by a heap of barium platino-cyanide crystals is also obtained by crossing two crystals [see Abstract No. 1257 (1900)]; one crystal alone appears yellow. This polarisation is not shown either by common or by freshly crystallised active barium platino-cyanide. In connection with the colouring of rock-salt and potassium bromide by radium rays, it may be mentioned that barium bromide kept in a closed vessel takes on a yellowish colour and gives a weak smell of bromine. The chloride also in the same way gives a smell of hydrochloric acid. G. E. A.

1999. *Radium Rays in the Electric Field.* **E. Dorn.** (Phys. Zeitschr. 1. pp. 337–338, May 5, 1900.)—The emission from a small quantity of radioactive barium bromide passes between the plates of a condenser 14 mm. apart, and impinges on a barium platino-cyanide screen 2 cm. above the condenser, producing fluorescence. It is found that the light always deviates towards the positive plate of the condenser like kathode rays. Assuming Becquerel's numbers, the displacement of the image is calculated considering the rays to consist of electrically charged masses moving with great velocity, and the observed displacement is considered to agree fairly well with the calculated value. A large part of the rays is absorbed by the positive plate by reason of the small distance of the plates apart, but a calculation gives 0·24 cm. and 0·33 as the respective displacements at the positive and negative sides. In the darkened room the displacement was difficult to measure, but appeared to be 2 or 3 millimetres. G. E. A.

2000. *Electric Fluorescence of Nitrogen.* **P. Lewis.** (Ann. d. Physik, 2. 3. pp. 459–468, July, 1900.)—When a vacuum tube is filled with nitrogen prepared from ammonium sulphate and nitrite, and deprived of oxygen by means of hot copper, the wall of the tube fluoresces for a few seconds under the influence of the discharge, and then ceases. The fluorescence extends not only over the whole interior of the tube, but also over the tubes through which the nitrogen is brought in and pumped out. It disappears soonest where the current is strongest, but can be made permanent by using a continuous stream of fresh nitrogen. Fluorescence is strongest at feeble currents and low pressures. That it is the glass and not the gas which fluoresces is shown by the fact that if a portion of the glass wall is heated it ceases to shine, and only recommences after it has cooled down. Small additions of oxygen, hydrogen, steam, or carbonic oxide diminish the fluorescence. But the purest nitrogen does not show it either, and the author believes that it is due to the admixture of some impurity to the nitrogen. To judge by the spectrum of the fluorescence, that impurity is either water or oxygen, but in exceedingly minute quantities. Very small impurities of oxygen are capable of producing an after-effect in the shape of a fluorescence lingering after the discharge has ceased. E. E. F.

2001. *Phosphorescence of Phosphorus Pentoxide.* **H. Ebert and B. Hoffmann.** (Zeitschr. Phys. Chem. 34. pp. 80–86, July 3, 1900.)—The phosphorescence of phosphorus pentoxide has usually been ascribed to the slow oxidation of lower oxides present as impurities. A green phosphorescence is, however, observed even in a vacuum or in an atmosphere of a neutral gas; also with specimens prepared by burning pure phosphorus in which no arsenic, antimony, copper, &c., could be detected, and which had been freed from lower oxides by subliming over red-hot platinum black in an atmosphere of dry oxygen, and were free from moisture and phosphoric acid. The phosphorescence is caused by blue as well as by ultra-violet rays. Commercial pentoxide gives a more persistent white luminescence due to oxidation of lower oxides, in addition to the green fluorescence. T. M. L.

HEAT.

2002. *Thermal Conductivity of Iron.* **E. H. Hall.** (Phys. Rev. 10. pp. 277–310, May–June, 1900.)—This paper is a critical study of the methods and results of the following experimenters: Forbes, Mitchell, R. W. Stewart; Ångström, Neumann, H. Weber; L. Lorenz, Beglinger; and Berget. The author entirely distrusts the results obtained by Forbes's method; he finds a slip in Ångström's final calculation which, when corrected, gives 0·1762 for the value of k at 0° C. in c.g.s. units when the constant value 0·8862 is retained for the specific heat at constant volume, and 0·1655 if allowance is made for the variation of the specific heat with temperature; he considers Lorenz's method particularly well designed for giving the temperature coefficient of variation of k, and Lorenz's number, — 0·0002282, as therefore pretty accurate; he especially eulogises Berget's guard-ring method, and communicates the results of some experiments of his own by this method, which give $k = 0{\cdot}1541\,(1 - 0{\cdot}0003t)$. He generally distrusts the measurements of temperature by the thermoelectric arrangements used, and laments the absence of exact data as to the density of the iron used, and finally discusses the relation of thermal to electrical conductivity. R. E. B.

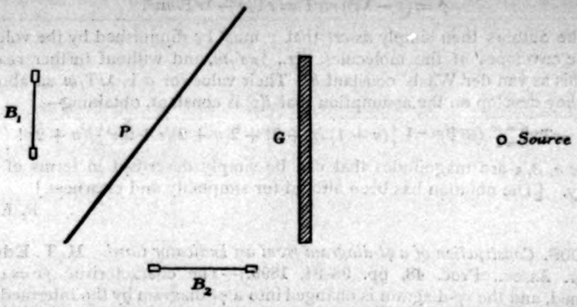
2003. *Platinum Gas Thermometer,* II. **L. Holborn** and **A. Day.** (Ann. d. Physik, 2. 3. pp. 505–545, July, 1900.)—For work at high temperatures the air thermometer with a platinum-iridium vessel is superior to a porcelain thermometer owing to the absence of softening; the permeation of the gas, which in the case of hydrogen is troublesome, is obviated by substituting nitrogen for air or hydrogen. In continuation of their previous work on the subject, the authors have determined the correction to be applied on account of the expansion of the vessel. This expansion, which demands a correction of 10°, 30°, and 40° respectively at 500°, 1,000°, and 1,150° is not regular, and a further error of 1·5° to 7° is occasioned by the irregularity. The curve of expansion was determined by measuring the expansion of a rod made of the standard alloy, containing 80 per cent. of platinum and 20 per cent. of iridium. With a nitrogen thermometer subjected to the new corrections a number of melting-points of metals were determined, so as to render future tests, especially those of thermo-elements, independent of the nitrogen thermometer. Thus the melting-point of lead was found to be 326·9°, of pure silver 961·5°, and of gold 1,064·0°. The last value was verified by an optical method, the refractive index of air exposed to the temperature of the melting-point being measured. This also gave 1,064°. [See also Abstract No. 1873 (1899).]

E. E. F.

2004. *Liquefaction of Gaseous Mixtures.* **F. Caubet.** (Comptes Rendus, 131. pp. 108–109, July 9, 1900.)—The author presents the results of his investigations on a third group of gaseous mixtures, giving the limiting lines and critical line of a series of mixtures of methyl chloride and sulphur dioxide. These lines afford a verification of previous theory, as they show the existence of the points and lines of Gibbs and Konowalow. Retrograde condensation has not been observed in this group. [See also Abstract No. 843 (1900).]

W. E. T.

2005. *Temperature of a Radiating Body.* **F. Kurlbaum.** (Ann. d. Physik, 2. 3. pp. 546–559, July, 1900.)—The temperature of the surface of a radiating body is usually supposed to be equal to that of the interior; but this is by no means strictly the case, especially when the body is a bad conductor and a good radiator. To determine the actual difference in a concrete case the author made an experiment, the principle of which is indicated in the annexed diagram, where P is a sheet of platinum foil 1μ thick, covered on both sides with platinum black. Light falls through the glass plate G upon the platinum, and the heated platinum sends heat rays to the bolometers B_1, B_2, placed symmetrically with regard to the sheet. Any difference between the temperatures of the two surfaces will be indicated by a difference in the deflections of the two bolometers. As a result, the author finds a difference of temperature of 0·016° when the sheet is heated 4° above its surroundings, and 0·068° when the sheet is blackened with lampblack instead of platinum black. This difference is, of course, only that which applies to the special case, but anyhow it is smaller than usually supposed. E. E. F.



2006. *Evaluation of van der Waals' Constants.* **P. A. Guye** and **L. Friderich.** (Archives des Sciences, 9. pp. 505–531, June, 1900.)—For 71 substances the constants a and b in van der Waals' form of characteristic are calculated from the experimentally found values of the critical pressure and temperature according to the known formulæ, the particular methods of calculation used being discussed at length. These calculations are made for the characteristic, both with volumes referred to that under unit pressure at 0° C. as unit (in which case it is found that the formula—

$$b = 0·0004496K_c + 0·000001835K_c^2,$$

where $K_c \equiv T_c/P_c$, is very approximately exact), and also with volumes referred to the gramme-molecule. R. E. B.

2007. *Meaning of van der Waals' Constant b.* **L. Boltzmann** and **H. Mache.** (Cambridge Phil. Soc., Trans. 18. pp. 91–93, April, 1900.)—If ν_1 and ν_2 are the numbers of simple and double molecules in a gas per unit volume, molecules of a higher concentration occurring in only negligible amount, formula (233) of Boltzmann's *Vorlesungen über Gastheorie*, without the restriction of χ being constant, gives—

$$\nu_2 = \lambda\nu_1^2, \text{ where } \lambda \equiv 2\pi\int_\sigma^{\sigma+\delta} ds\, s^2 e^{f(s)/mrT},$$

m being the mass of a simple molecule, r the constant for the gas, and T the absolute temperature.

Then $p = (\nu_1 + \nu_2)\, mrT$, while the total mass of the molecules is $(\nu_1 + 2\nu_2)\, m \equiv 1/v$, v being the specific volume; these give—

$$\nu_1 + 2\nu_2 = 1/mv \equiv x, \quad \nu_1 + \nu_2 = p/mrT \equiv y,$$

and thus—

$$x - y = \lambda \left\{x - 2(x - y)\right\}^2 \triangleq \lambda x^2,$$

if $x - y$ is small compared with $\frac{1}{2}x$, *i.e.*, if ν_2 is small compared with $\frac{1}{2}\nu_1$; and consequently—

$$p = (x - \lambda x^2)\, mrT = rT/v - \lambda rT/mv^2.$$

The authors then simply *assert* that v must be diminished by the volume of the envelopes of the molecules, viz., $\frac{4}{3}\pi\sigma^3/m$, and without further reason put this as van der Waals' constant b. Their value for a is $\lambda rT/m$ as above; this they develop on the assumption that $f(s)$ is constant, obtaining—

$$\alpha rT\Sigma_{n=1}^{n=\infty} (\beta/T)^{n-1} \left\{(n + 1)(n + 2) + 2(n + 2)/\epsilon + 2/\epsilon^2\right\}/(n + 2)\,!$$

where α, β, ϵ are magnitudes that can be simply described in terms of the theory. [The notation has been altered for simplicity and clearness.]

R. E. B.

2008. *Construction of a φt-diagram from an Indicator Card.* **H. T. Eddy.** (Amer. Assoc., Proc. 48. pp. 93–94, 1899.)—The characteristic $pv = ct$ is assumed, and the *vp*-diagram is changed into a *φt*-diagram by the intermediate use of a *vt*-diagram. R. E. B.

2009. *Characteristic of Steam.* **O. Tumlirz.** (Akad. Wiss. Wien, Sitzb. 108. pp. 1058–1069, 1899.)—Battelli's results from −6·16° C. to 231·41° C. are represented by the equation—

$$p(v + 0{\cdot}008402) = 3{\cdot}4348T$$

as exactly as by that of Clausius' type which Battelli gives, except in the immediate neighbourhood of the points of condensation. Within these limits, then, superheated steam is a perfect gas in so far that its intrinsic energy is a function of the temperature only, since $(\partial E/\partial v)_T = (\partial p/\partial T)_v - p = 0$. Pushed to the points of saturation this formula gives volumes that are too great or too small according as the temperature is below or above 49·46° C. R. E. B.

2010. *The two Specific Heats of Steam.* **O. Tumlirz.** (Akad. Wiss. Wien, Sitzb. 108. pp. 1395–1405, 1899.)—The characteristic found for superheated steam (see preceding Abstract), of the form $p(v + a) = RT$, requires the two specific heats to depend, if they vary at all, on the temperature only, and their difference in dynamical measure to be equal to R: adiabatic expansion from p,T to p',T′ with this characteristic also gives $\int_T^{T'} (K/T)dT = R \log(p'/p)$ where K is the isopiestic specific heat. But Grashof showed that Hirn and Cazin's experiments give $\log(p'/p) = n \log(T'/T)$, where n is a constant; hence therefore $K = Rn$, or both specific heats are constant. The author finds 4·3045 as the best value of n, and thus, in heat units—

$$C = (3{\cdot}4348 \times 13{\cdot}596 \div 424) \times 4{\cdot}3045 = 0{\cdot}4761,\ c = 0{\cdot}3639,\ C/c = 1{\cdot}3026.$$

The work done by the internal forces in the particular case when steam becomes saturated at 137·34° C. is then found to be equivalent to 3·461 calories, on the assumption [see Abstract No. 624 (1898)] that in the neighbourhood of saturation C = 0·5286, Planck's value 0·47 being rejected for reasons given.

R. E. B.

2011. *The Calculus of Probabilities as Applied to Dynamical Systems.* **E. Zermelo.** (Phys. Zeitschr. 1. pp. 317–320, April 14, 1900. Göttinger Habilitationsvorlesung, March 4, 1899.)—The author objects to the assumptions that have hitherto been made in the kinetic theory of gases for the determination of probabilities and average values on the ground that they are taken to be applicable at *all* stages of the motion, whereas, the changes in the motion being due to fixed mechanical laws, the possible applicability of these assumptions at one stage does not necessarily entail their applicability at a subsequent stage. Now the probability of any state of motion is necessarily equal to that of the initial state from which it originated, so that the probability is independent of the time; we may thus define the probability that a particular state of motion at time t lies within a given range of possible states g, which are included within the whole range G that comes into consideration, as the ratio γ/Γ of the "extents" of these ranges, which are defined as the $2n$-ple integral $\int\Pi dp\,\Pi dq$ taken over the respective ranges, where q denotes the type position-variable, p the corresponding momentum, and Π the continued product of similar magnitudes; since, by Liouville's theorem, these extents do not alter with the time. It then follows that (1) the average value of dS/dt in every invariable range G, where S is any single-valued differentiable function of the state of motion, is zero; (2) if σ is an approximation to a value S_0 of the single-valued function S, the average value of dS/dt within the range given by $S_0 - \sigma < S < S_0 + \sigma$ is zero. The author proposes to reinvestigate Maxwell's law from the above definition of probability without any further hypothesis. R. E. B.

2012. *Reduction of Problems of Heating by Radiation to that of Heating by Contact. Heating of a Wall of Infinite Thickness.* **J. Boussinesq.** (Comptes Rendus, 130. pp. 1782–1786, June 25; 131, pp. 9–13, July 2; and pp. 81–86, July 9, 1900.)—In his former paper [see Abstract No. 1820 (1900)] the author gave as an example of his theory the case of a wall of infinite thickness bounded by the plane $x = o$, originally given at temperature zero, and heated by an external source producing on that face the temperature $u = f(t)$, where $f(t)$ is an arbitrary function of the time. In the present paper he gives a second example, namely, that of a wall of infinite thickness bounded by the plane $x = o$, and originally at temperatures denoted throughout its thickness by an arbitrary function of x, tending towards a constant as x becomes infinite. The mathematical difficulties of the subject are due, says the author, to the employment by Fourier, on whose formulæ the investigation is based, of sines and cosines of real arcs, and consequently of undulations, which can have no place in a uniform state. It becomes necessary to eliminate these unnecessary undulations.

In pp. 9–13 the author proposes to give two examples of permanent heating. In the first example the wall is bounded by the infinite surface $x = o$, but the external temperature u_e on that face is a function of y and z. This is intended to lead up to the case of the temperature of the earth's crust, under the (supposed constant) action of the sun, assuming that owing to diversities of the atmospheric conditions local inequalities of temperature exist. It is shown that the local inequalities of temperature diminish as we proceed inwards from the surface, and become insensible at a depth considerable in relation to the spaces on the surface over which the local inequalities exist.

In pp. 81–86 the author treats of a homogeneous sphere, radiating into space, the temperature of which, while invariable with the time, has given values u_e at different points of the surface. The origin being taken at centre of the sphere, and R being the radius, the problem solved is to form a function u which shall have the value zero at the centre, and vary continuously to u_e at each point on the surface. S. H. B.

2013. *Cooling of the Earth's Crust.* **J. Boussinesq.** (Comptes Rendus, 130. pp. 1652–1658, June 18, 1900.)—The writer refers to his former paper [see Abstract No. 1820 (1900)] in which he found the formula $\int_{\omega}^{\infty} \epsilon^{-\omega^2} d\omega$ to express the temperature of a body of infinite extent, bounded by a plane surface, raised to a uniform temperature u_o and then left to cool by radiation from that plane surface into space supposed at zero. The temperature on the surface is given by—

$$u = \frac{2u_o}{\sqrt{\pi}} \epsilon^{a^2h^2t} \int_{ah\sqrt{t}}^{\infty} \epsilon^{-\omega^2} d\omega$$

and this becomes approximately, for large values of t, $\frac{u}{ah\sqrt{\pi t}}$.

These two formulæ are precisely those obtained by Fourier to express the successive temperatures on the earth's surface (not taking into consideration the sun's action) from which formulæ Fourier deduces his theory of the cooling of the earth. The author discusses this theory. The effects due to solar action will be periodic, in daily or yearly periods, and will at considerable depths become insensible. The temperature of surrounding space will be the same, he says, at the poles as at the equator, and will continue unchanged throughout long periods of time. Treating this temperature of space as zero, the equations representing the earth's temperature are—

$$\frac{du}{dx} - hu = o \text{ (for } x = o\text{)}$$

and—

$$\frac{du}{dt} = a^2 \frac{d^2u}{dx^2}.$$

The author, making an actual calculation on certain hypotheses, obtains 45,000 centuries as the time which may have elapsed since the earth's surface had a temperature of 1,000° C. S. H. B.

SOUND.

2014. *Photography of Sound Waves.* **R. W. Wood.** (Roy. Soc., Proc. 66. pp. 283–290, May 12, 1900. See also Nature, 62. pp. 342–349, Aug. 9, 1900, for an extended account.)—The sound-waves are produced by means of an electric spark, and illuminated and photographed by the light of a second spark properly timed with reference to the first. The author remarks that in a former paper [see Abstract No. 89 (1900)] he treated of photographs of sound-waves undergoing reflection, refraction, and diffraction; but by means of an improved apparatus he has obtained a more complete series of photographs.

Conjugate foci for elliptical mirrors aplanatic for rays issuing from a point, the transformation of a spherical into a plane wave by a parabolic mirror, and the effect of spherical aberration in circular mirrors are well shown. The transformation of a spherical wave into a plane wave by a cylindrical carbonic acid lens of exceedingly thin collodion, the circular flat ends being made of mica, can also be demonstrated, and the reflection of a single wave from a flight of steps forming a train of waves, in other words, a musical note.

In dealing with the reflection of a plane wave from a hemispherical mirror, being unable to control the time interval between the sparks with sufficient accuracy to take a series of photographs of an actual wave suitable for kinematographic reproduction, the author adopts the expedient of preparing a large number of geometrical constructions (100 or so) for the wave at successive intervals of time and photographing them upon a kinematographic film. The wave fronts are constructed as follows: Around points upon the surface of the mirror circles are described tangential to the plane wave; these circles will be enveloped by another surface behind the mirror (the orthogonal surface), which is an epicycloid formed by the rolling of a circle of diameter equal to the radius of the mirror upon the back surface of the same. Normals to this orthogonal surface can be constructed by drawing the locus of the centre of the generating surface, describing about various points of it circles whose radii shall be equal to the radius of the mirror, and joining the points where each circle cuts the epicycloid and the mirror respectively. These normals will represent the reflected rays, and if equal distances be measured off upon them from the orthogonal surface, the points so found will lie upon the reflected wave fronts. After a time a second reflection will occur, and to determine the wave front for it measurements have to be made round a corner. Photographs are given of the waves and a figure to show the construction for the wave-front. W. C. O.

ELECTRICITY.

THEORY AND ELECTROSTATICS.

2015. *Robin's Method of Defining Electrostatic Potential.* **E. Neumann.** (Gesell. Wiss. Göttingen, Nachr., Math-Phys. Klasse, 3. pp. 291–301, 1899.)—We are to suppose a closed surface σ of any form subject (according to Robin) to the condition of being everywhere convex: p is any point either in the enclosed or in external space, and r_p is the distance from p of any point on the surface σ, or in free space. If there be on σ a distribution of density g_σ, $V_p = \frac{1}{2\pi}\int g_\sigma \frac{d\sigma}{r_p}$, then V_p is the potential of that distribution, and $\left(\frac{dV}{d\nu}\right)_i$ and $\left(\frac{dV}{d\nu}\right)_a$ are the usual derivatives of V in the normal torwards the internal or external space respectively. Then form a new distribution on σ, of density equal to the arithmetic mean of $\left(\frac{dV}{d\nu}\right)_i$ and $\left(\frac{dV}{d\nu}\right)_a$, and call that g'_σ. Then V'_p is the potential of the new distribution g'_σ. And so we form the series of successive potentials V_p, V', V^n_p. Robin's theorem asserts that the series $V_p + V'_p + \cdot$ &c., is convergent.

Neumann then considers a class of integrals, to which attention was called by Schwarz. If $V^{(\kappa)}$ and $V^{(\lambda)}$, Schwarz's integrals, be two members of the series of V'_s—and if we form the integral

$$\int\left(\frac{dV^{(\kappa)}}{dx}\frac{dV^{(\lambda)}}{dx} + \text{\&c.}\right)d\tau$$

throughout either the internal or external space it is found that the result depends only on the sum $\kappa + \lambda$, and so may be written $L^{(\kappa+\lambda)}$. It follows that if $\kappa + \lambda$ be even, L^{2n} is positive, and approaches a limit as n increases.

The author generalises this theorem, forming two series of V'_s, and taking in each case $V^{(\kappa)}$ from one and $V^{(\lambda)}$ from the other series. It is found that in this case also the result depends only on $\kappa + \lambda$. Using now special forms of g for the two series, the author obtains a simplification of Poincaré's generalisation of C. Neumann's method of the arithmetic mean, and shows that the convexity of the surface σ is not an essential condition, provided that at each point each principal radius of curvature is finite and continuous. Finally the author discusses the consequence of Robin's series. S. H. B.

2016. *Thermodynamics of Cells.* **C. Liebenow.** (Ann. d. Physik, 2. 3. pp. 636–648, July, 1900.)—Riecke and others have postulated the generation of an electric current by every heat current, and *vice versâ*. [See Abstracts Nos. 1516 (1899), and 138 (1900).] The author attempts to account for this by assuming that the heat consists in the vibrations of the negative particles, now usually called electrons. Anything which moves these negative electrons will move the heat attached to them by convection, and so every electric current will go hand in hand with a heat current. The heat can be calculated from the equation—

$$\Phi = -0{\cdot}24\,\mathrm{T}i\frac{d\mathrm{E}}{d\mathrm{T}},$$

which gives the amount of heat conveyed by a current i through any cross-section of the metal in one second. For copper, the amount of heat thus supplied to each gramme-atom precipitated from solution would be 870 calories at 0°. But since the total heat of the gramme-atom is about twice that amount, it may be said that half the total heat of the metal is conveyed by the negative electron, and the other half by the positive electron. The author further shows that all metals in the solid state are monovalent, and that the atomic heat of negative and positive electrons is $870/273 = 3{\cdot}2$, or about the same as the atomic heat of monatomic gases at constant volume.

E. E. F.

2017. *Thermo-magnetic Action.* **W. Voigt.** (Gesell. Wiss. Göttingen, Nachr., Math-Phys. Klasse, 3. pp. 302–305, 1899.)—The author refers to two former works of his own (Gött. Nachr., 1895, p. 135, 1898, p. 113.) Experiments show, he says, that in thermo-magnetic processes two kinds of action are in evidence—one reversible, the other irreversible. These are distinguished by separate linear equations of the form—

$$\left.\begin{aligned} \mathrm{X} &= -\theta\,\mathrm{R}\frac{d\tau}{dy}, \\ \mathrm{Y} &= +\theta\,\mathrm{R}\frac{d\tau}{dx}, \\ \mathrm{Z} &= 0, \end{aligned}\right\}\text{for the reversible actions}$$

where the magnetic field is in direction Z—X, Y, Z are components of E.M.F., and θ is a constant dependent on the nature of the substance. Analogous equations hold for the flow of heat consequent on the electric current whose components are u, v, w. For the irreversible actions he gives the equations $\mathrm{X}' = -\nu\,\theta'\mathrm{R}\frac{d\tau}{dy}$, $\mathrm{Y} = \nu\,\theta'\mathrm{R}\frac{d\tau}{d\lambda}$, where ν is a parameter parallel to Hall's rotation coefficient, and $\theta' = \frac{d\theta}{d\mathrm{T}}$.

If $\Phi = \theta - \mathrm{T}\theta'$, then $\sigma = \frac{d\Phi}{d\mathrm{T}}$ is Thomson's "specific heat of electricity." These formulæ are compared with the results of experiments by Ettinghausen, Nernst, and Everdingen. The author also refers at some length to a work by Moreau, who, without being aware of the author's work, obtained results which in the main agree with his: one point of difference is discussed.

S. H. B.

2018. *Atmospheric Electricity.* **J. Elster** and **H. Geitel.** (Phys. Zeitschr. 1. pp. 245–249, March 3, 1900. Paper read before the Brunswick Scientific Society by H. Geitel, Nov. 16, 1899.)—Normal atmospheric airs contains nearly equal numbers of positive and negative ions. A positively charged conductor attracts the negative ions, and a negatively charged conductor the positive ions, and the conductor is gradually discharged by them. Fog destroys the mobility of the ions by attaching them to water drops. In the earth's electrostatic field the free ions undergo a partial separation. Positive ions gather about the mountain-tops, and produce a discharge of negative electricity from them. An unimpeded acquisition of negative electricity takes place on the earth's surface wherever the negative ions penetrate below the surface, as they practically do when they descend below the foliage in a forest. This may account for the earth's permanent negative charge. Since a cloud stops the mobility of ions, and interferes with their steady diffusion, it may produce the accumulation of large quantities of electricity, which are only neutralised by disruptive discharges. The daily periodic variation of atmospheric electricity may be explained by the varying amount of moisture condensed in the air. For a full ionic theory of atmospheric electricity a considerable amount of material remains to be accumulated. E. E. F.

2019. *Inductance and Electrostatic Oscillations.* **P. de Heen.** (Comptes Rendus, 130. pp. 1071–1072, April 17, 1900.)—On the ordinary phenomena of electrostatic *influence* there appears to be superposed in certain cases a phenomenon of inductance comparable to that of electro-dynamics.

If a charged conductor is caused to approach another conductor, or if the first conductor is charged or increased in potential, the second conductor becomes charged with electricity of the same kind. The result is reversed when the inverse operations are performed. A conductor set in motion in the neighbourhood of a second conductor tends to displace itself in the inverse sense of the motion communicated to it.

Consider a gold-leaf electroscope *of which the conductor is joined to earth* and place under these conditions, at a *distance determined* and relatively small, the *positive* conductor of a Leyden jar. The electroscope being set in action the phenomenon of influence manifests itself and the gold-leaves separate with a quantity relatively feeble. Influence is manifested only.

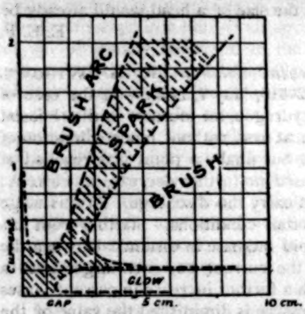
If, in the second place, the electroscope being discharged and the Leyden jar being at a great distance, this latter is caused to approach up to the distance which corresponds to the first experiment, the phenomenon of *inductance* is produced, the gold-leaves diverge with a quantity *incomparably greater* than in the first experiment, and the electroscope is charged *positively.*

In the third place, perform the first experiment, then withdraw the jar slowly. At a certain moment *influence* will cease to be sensible and the gold-leaves will come together. If, however, the movement of the jar is continued the electroscope becomes *negatively* electrified by *inductance,* and the gold-leaves separate anew.

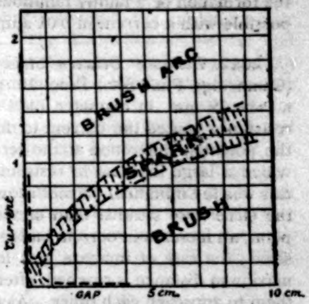
It results from this that if we determine an oscillation of potential, this oscillation will transmit itself to a distance, very probably by *inductance* and not by *influence,* and if *one* of the poles of a strong coil worked by a Wehnelt interrupter is put in communication with a stretched copper wire, or with a square of large wire gauze, the electromagnetic oscillations developed are capable of illuminating a vacuum tube enclosed in a thick pasteboard box. A very sensitive radio-conductor permits of recognising the absence of the electromagnetic oscillation. J. J. S.

DISCHARGE AND OSCILLATIONS.

2020. *Continuous Discharges in Air.* **M. Toepler.** (Ann. d. Physik, 2. 3. pp. 560–623, July, 1900.)—When a battery of cells is used as a source of electric energy, the constant element in the circuit is the E.M.F.. while the current depends upon a variety of external conditions. The case is reversed on using an influence machine driven at a constant speed, for then the mean current strength is the constant element, and the E.M.F. is the dependent variable. The author investigates the conditions of the generation of a continuous discharge in air at atmospheric pressure as dependent upon the current strength. This continuous discharge may appear in four different forms, viz., glow, brush, brush-arc, and flame-arc. All of these may be either positive or negative, and the relative importance of the positive and negative phenomena depends upon the capacity and shape of the electrodes. To simplify matters, the author supposes that one side of the discharge is highly developed at the expense of the other, so that either the positive or negative discharge takes up practically the whole field. This may be brought about, for instance, by opposing a good pointed conductor to a bad and flat conductor, such as a slate.



POSITIVE DISCHARGE.



NEGATIVE DISCHARGE.

As a general rule, an increase in the current strength brings about a transition from the glow to the brush and from the brush to the brush-arc discharge. But this transition is only continuous when the capacity in the circuit is very small. At greater capacities, the three regions of continuous discharge are separated by two regions of discontinuous (spark or line) discharge. In the diagrams, the regions of discontinuous discharge are shaded. The diagrams represent the conditions obtaining with 10 cm. of capacity in the circuit, the current bring expressed in milliamperes. With higher capacities, the shaded region encroaches very considerably upon the brush-arc region, especially in the positive discharge. E. E. F.

2021. *Globe Lightning.* **M. Toepler.** (Ann. d. Physik, 2. 3. pp. 623–635, July, 1900.)—This is an appendix to the paper referred to in the preceding Abstract. The author points out that two more or less continuous forms of electric discharge occur in nature. One is the glow discharge known as St. Elmo's fire, the other is that known as globe or ball lightning. The nearest experimental analogue of ball lightning is the brush arc, including the special forms of it described by Righi and others, more especially those observed under slightly reduced pressure. The author regards globular lightning as a short continuous lightning discharge along the path previously cleared by "fork" lightning. The globe marks a portion of the lightning track where there is a particularly high potential gradient. The shape, as gathered from the descriptions, is always somewhat elongated. The motion of the mass is accounted for partly by electrostatic forces similar to those which displace a shower of sparks, and partly by the motion of the air, which displaces and deforms the track. The "foot" of the track may be displaced for a considerable distance, thus giving the impression of a free wandering of the globe, and the steady discharge may be kept up for some 80 seconds under favourable circumstances. As a rule, another spark discharge (ordinary lightning) ends the display, and the detonation is usually attributed to the ball itself. As regards the current intensity in globe lightning, that may possibly at some moments amount to 10,000 amperes. But the more usual current intensity does not exceed some 5 amperes, as may be judged from the size of the globe (that of a hen's egg or a child's head) and from its duration as compared with the brush-arc and forked-lightning flash. But globe lightning is possible even at much lower currents. To judge from laboratory analogies, the formation of a faintly luminous mass the size of a head would already be possible with a current of 0·01 ampere. E. E. F.

2022. *Distance Between Striæ in Positive Column.* **R. S. Willows.** (Cambridge Phil. Soc., Proc. 10. pp. 302–316, May 7, 1900.)—In the case of a tube 12 mm. in diameter filled with hydrogen, an increase in the rheostat resistance caused the current to decrease at first, without much alteration of the potential difference at the terminals, but finally a point was reached at which a large increase in resistance caused no further decrease in current; this was the minimum current required to carry the discharge. At this stage the striæ were steadier than under any other conditions. Starting from this point, an increase in current causes a rapid increase in distance between the striæ; the rate of increase gets less as the current becomes larger until a maximum distance is reached, after which a further increase in current causes them to approach each other. As the pressure is diminished the value of the maximum distance increases, but the strength of current required to produce it becomes less, so that at pressures of a few tenths of a mm. that phase in which an increase of current produces a separation of the striæ may be nearly absent, and the current required to produce the maximum separation is nearly equal to the smallest current required to maintain the discharge. The presence of this maximum explains the observation of Müller and de la Rue, that sometimes an increase in current causes the striæ to separate, while in other cases the reverse effect is obtained. With air and nitrogen the effect is rather different. Starting from a current just large enough to maintain the discharge, an increase causes a rapid separation of striæ nearly proportional to the current until the latter is nearly four times its original amount, after which the distance between is constant.

With respect to the effect of pressure, Goldstein from his measurements deduced the following law: If d is the distance between two striations and ρ the density of the gas, then, for a given gas, d varies as ρ^{-n} where n is somewhat less than unity. The author finds that the sides of the tube exercise a controlling action and that Goldstein's law may be more accurately replaced by the following: If the striæ do not reach to the edge of the tube, then, for the same current, their distance apart varies inversely as the pressure.

At pressures between 1 mm. and 0·5 mm. the striæ are further apart in hydrogen than in nitrogen and air: for the last two gases the separation is the same. The rate at which the distance between successive striæ decreases as the pressure increases is much greater in the dense gases, and is greater in wide tubes than in narrow ones.

The striæ are further apart the wider the tube, but the distance between bears no simple relation to the diameter or section of the latter. Goldstein's second law, "That if d is the distance between the striæ, then the ratio of the two values of d at two given pressures is the same for all tubes," is very approximately true when the discharge reaches to the sides of the tube, but does not hold when the distance between the striæ varies inversely as the pressure; in this case the ratio is greater for wide tubes than for narrow ones. D. E. J.

2023. *Ionic Conductivity of the Atmosphere.* **J. Elster** and **H. Geitel.** (Ann. d. Physik, 2. 3. pp. 425–446, July, 1900.)—Observations made with an electroscope protected against wind and rain but exposed to ordinary air show that the dissipation of an electric charge is due to the presence of ions in the atmosphere. The presence of fog, smoke, or dust reduces the rate of discharge instead of increasing it. The discharge is also reduced by enclosing the electroscope in a limited air space, probably owing to the limited number of ions originally contained in the latter. The dissipation of positive and negative charges takes place at approximately the same rate, except at high altitudes, such as the Brocken and the summit of the Säntis, where the rate of dissipation may be from two to ten times as great for negative as for positive charges. The authors connect this observation with the fact that ultra-violet light ionises the air, and that therefore the highest strata of the atmosphere are probably ionised by the sun's rays. The ions thus produced are diffused through the atmosphere at rates depending upon their velocities. Such ions would account for the conductivity of the atmosphere at high elevations, and explain to some extent the luminous and magnetic phenomena of the aurora. E. E. F.

2024. *External Electric Field of a Discharge-Tube.* **F. Schicht.** (Akad. Wiss. Wien, Sitzb. 108. pp. 814–824, 1899.)—The fall of potential inside a discharge-tube has been carefully examined, but apparently the electrostatic field in the air-space surrounding the tube has not hitherto been investigated. The author's experiments were made with three tubes of lengths 17·5, 36·5, and 71 cm. respectively: the anodes were points and the kathodes were circular discs 2·5 cm. in diameter. He deduces the following conclusions: (1) The potentials decrease when the distance from the tube increases, and are greatest in the immediate neighbourhood of the tube. It is, however, remarkable that the maximum value is not near the anode, but about half-way along the tube. (2) As the pressure diminishes the potentials also diminish at first to a minimum (when striation begins) and then increase. (3) The potentials are higher when a spark-gap is introduced than when it is absent. (4) When the discharge takes place in a magnetic field (lines of force perpendicular to path of discharge) the potentials are higher than under ordinary circumstances. D. E. J.

2025. *Spark Due to Break.* **K. R. Johnson.** (Electrician, 45. pp. 281–282, June 15, 1900.)—For a circuit composed of coil, battery, and make and break, the terminals of which are connected to the coatings of a condenser, the equations for the extra current,

$$L\frac{dI}{dt} + RI = -E$$

and—

$$I = C\frac{dE}{dt}$$

are integrated and an expression is found for the maximum E.M.F. between the terminals. The terms of the expression are considered in so far as they influence the suppression of the spark, and, a similar expression being deduced from a formula of Heaviside's for the potential at a point on a cable, it is argued that there is little difference, in considering the spark or its suppression, whether the condenser is situated at the ends of the broken circuit or the capacity of the circuit is uniformly distributed. And as every practical case is intermediate between these extremes the reasoning may be true for a circuit in general. G. E. A.

2026. *Disruptive Discharge Phenomena.* **W. J. Humphreys.** (Phys. Rev. 10. pp. 311–316, May–June, 1900.)—When the poles of an influence machine are separated beyond the ordinary limits of sparking, a spark can be caused to pass, sometimes through nearly double that distance, by drawing a small spark, by the knuckle, or otherwise, from the negative pole. The spark between the poles is then either a disruptive or a brush discharge. It is important that the outer coatings of the Leyden jars of the machine should be connected by a conductor. Nothing of the kind occurs when those coatings are insulated from each other, nor when the auxiliary spark is taken from the positive instead of from the negative pole of the machine. The author admits that the effect is the result of surging, but he points out that it is not clear why the oscillations should not be equally great for positive and negative impulses. R. A.

2027. *Theory of Electric Waves in Wires.* **G. Mie.** (Ann. d. Physik, 2. 2. pp. 201–249, June, 1900.)—Instead of the case of a single wire surrounded by a hollow cylinder serving as a return circuit, the author deals with two infinite parallel wires in which the displacement currents in the insulating medium parallel to the conductor are negligible. This gives a theoretical approximation to Lecher's wire system.

For very slow oscillations, the velocity of propagation and the damping may be calculated in a simple manner from R, the resistance of the conductor; L, its inductance; C, its capacity, and A, the reciprocal of the insulation resistance, all per unit of length. For if I is the current intensity and P the line integral of the electric force between the two conductors, t the time, and z the distance along the wire from an arbitrary origin, the following two equations hold good—

$$\left.\begin{aligned} -\frac{dI}{dz} &= C\frac{dP}{dt} + AP \\ -\frac{dP}{dz} &= L\frac{dI}{dt} + RI \end{aligned}\right\} \qquad (1)$$

All the quantities are supposed to be measured in electromagnetic units. The equations imply that the electric circuit is a closed curve and that the line integral of the electric force round a closed curve equals the change in time of the magnetic flux through the curve. They are Maxwell's equations in a simplified and special form.

Putting—

$$I = C_1 . e^{2\pi int - \left(\frac{2\pi}{l} - \kappa i\right) iz},$$

$$P = C_2 . e^{2\pi int - \left(\frac{2\pi}{l} - \kappa i\right) iz},$$

where n is the frequency, l the wave-length, and κ the damping factor, equations (1) give—

$$\left(\frac{2\pi}{l} - \kappa i\right)^2 = -(R + 2\pi inL)(A + 2\pi inC) \qquad (2)$$

Denoting the radius of the wires by a, the distance between their axes by $2a$, the conductivity of the wire by λ_i, that of the insulator by λ_a, and its dielectric constant by ϵ, and putting the permeability, μ, of the wire equal to that of the insulator, we get—

$$\left.\begin{aligned} R &= \frac{2}{\pi a^2 \lambda_i} \\ L &= 4\mu ln \frac{2a}{a} + \mu \\ A &= \frac{\pi\lambda_a}{ln \dfrac{a+\sqrt{a^2-a^2}}{a}} \\ C &= \frac{1}{9 \times 10^{20}} \frac{\epsilon}{4ln \dfrac{a+\sqrt{a^2-a^2}}{a}} \end{aligned}\right\} \quad (3)$$

These values only apply when the oscillations are so slow and the wire so thin that the section of the wire may be supposed to be traversed by the current in a uniform manner.

The author proceeds to show that as long as the displacement current in the insulator parallel to the wires is negligible, equation (2) remains in force, and also the values for A and C in equations (3), but that when the oscillations become rapid, additional terms, dependent upon n, must be added to R and L, chiefly owing to the reduction of the effective sectional area; then, however, n becomes large also owing to a difference in the arrangement of the magnetic lines of force outside the conductor. But if the displacement current also takes a part in the return circuit, not only L, but also A and C are thereby affected, and in equation (2), which still remains in force, the imaginary quantity i must be replaced by a more complex term.

The author's results are calculated for an infinite pair of wires, but a finite ending simply introduces a radiation into space and a partial reflection which obeys the same laws as those of the primary oscillation. E. E. F.

2028. *Increase of Resistance of Radio-conductors.* **É. Branly.** (Comptes Rendus, 130. pp. 1068–1071, April 17, 1900.)—An account of the repetition of previous experiments (1891) on the increase of the resistance of certain radio-conductors under electric influences which generally produce diminution of resistance. The author has been confirmed in his opinion that the increase of resistance depends, like the diminution, on a physical condition of the insulating layers interposed. In one of the experiments a tube containing filings of pure gold was placed between two rods of pure gold, and its resistance before any electric action was found to be 400 ohms. A current was sent for thirty seconds from a battery through the radio-conductor and a column of liquid of 3,000,000 ohms resistance. With a battery of 8 volts the resistance became 160 ohms, and decreased with increasing battery power to 25 ohms when the E.M.F. was 160 volts. When, then, the spark from a small Wimshurst machine was caused to act at a distance and brought gradually nearer, the resistance finally fell to 6·5 ohms. On touching the tube containing the filings with one of the poles of the machine the resistance *increases;* it became gradually greater than 10,000 ohms. Under similar treatment a tube containing peroxide of lead exhibits increasing resistance as the battery power is increased; and the resistance increases when the spark from an electrical machine is brought gradually nearer. J. J. S.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

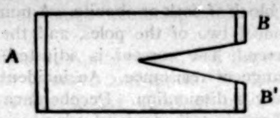
2029. *Dielectric Strength of Oils.* **T. Gray.** (Amer. Assoc., Proc. 48. pp. 122–123, 1899.)—The paper gives the results of experiments to determine the dielectric strengths of oils in layers of varying thickness. The variations of dielectric strength under continued electric stress made the results very irregular, and drying the oils by calcium chloride did not remove the trouble, but reduced the dielectric strength. The average of a large number of results shows that the dielectric strength per cm. thickness decreased slightly with the thickness of the layer. For thicknesses of from 1 to 8 cm. the dielectric strength of vaseline decreased from 131 to 91 kilovolts per cm.; paraffin, sp. gr. 0·28, from 91 to 70; ditto, sp. gr. 0·29, from 101 to 64; natural West Virginia crude oil, sp. gr. 0·29, from 81 to 62. G. H. B.

2030. *Hysteresis in Liquid Dielectrics.* **A. Artom.** (Elettricità, Milan, 19. pp. 374–375, June 16, 1900.)—The author has repeated for liquid dielectrics Arnò's experiments on hysteresis in solid dielectrics, observing the rotation of a film of the liquid in a rotating electrostatic field. The film of liquid was produced by covering a small cylinder of tin-foil (2 cm. × 1 cm. in diameter) with fine copper gauze, and immersing the cylinder in and filling it with the liquid. The cylinder was suspended by a silk fibre in an electrostatic field of from 10,000 to 12,000 volts with a frequency of 42, and was found to rotate with varying velocities according to the liquid employed. G. H. B.

2031. *Electrical Resistance of Gases.* **W. Kaufmann.** (Phys. Zeitschr. 1. pp. 348–349, May 12, 1900.)—The only directly measureable or comparable magnitudes are the current (C) and the electromotive force (E), and the resistance (R) is the quotient E/C or dE/dC. The two quotients are identical and the resistance is constant only when the current is proportional to the E.M.F. Three methods have been used for measuring the resistance of gases. I. A current of any value C is sent through the gas. The gas is then replaced by a metallic resistance R, which allows the same current to pass. Or the electromotive force E, which produces this current, is measured and then $R = E/C$. In general it is found that R is not independent of C. II. Arons and others have placed the gas and the source of current in a Wheatstone's bridge, using an alternating current and a telephone, and replacing the gas by a metallic resistance R. R is then equal to dE/dC. The values of R obtained by the two methods are not the same: the second method may even give negative values. III. A calorimetric method has also been used, especially for oscillatory discharges: here the relation of R to C is quite different to what it is in metallic closed circuits. Thus we can only assign an arbitrary meaning to the so-called "resistance" of a gas, and the best plan is to adhere to measurements of E and C and to relations between these which can be empirically determined. D. E. J.

2032. *Hall Effect.* **P. Moretto.** (N. Cimento, 11. pp. 278–290, April, 1900. Paper read before the Società Italiana di Fisica.)—The objects of the experiments described are: (1) To decide if for weak currents the Hall-effect remains proportional to the intensity of current passing through the metallic film; and (2) to decide whether the Hall-effect takes place when the metallic film is traversed by the instantaneous currents of condenser-discharges. The feeble currents employed were measured by a slight modification of Cardani's alkalimetric method [see Abstract No. 1156 (1898)]. The

Hall-effect was studied in the cases of gold- and bismuth-leaves prepared according to Righi's method. Each, in one set of experiments, consisted of a rectangle 15·95 mm. long by 13 mm. wide, one end being bifurcated. On each were three electrodes of tin-foil, A, B, B′, to which conductors were connected. A was connected to a battery of accumulators, and the current divided. Each section was connected to a separate electrolytic meter; then the two branches rejoined and the current returned to the battery. Each experiment was divided into four stages. The partial currents were measured (1) without any magnetic field; (2) with the magnetic field exerted; (3) with the field reversed; (4) without any magnetic field. Calling i_1 and i_2 the intensities of the currents in the respective branches when there is no field; $(i_1 + \alpha_1)$ and $(i_2 - \alpha_2)$ the intensities when the field is in one direction; and $(i_1 - \beta_1)$ and $(i_2 + \beta_2)$ the intensities when the field is reversed; it is clear that the current due to Hall's Phenomenon in one case equals $-(\alpha_1 + \alpha_2)$ and in the other $(\beta_1 + \beta_2)$. These two values are not exactly equal, but we may say that the entire variation, $\omega = \frac{1}{2}(\alpha_1 + \alpha_2 + \beta_1 + \beta_2)$. The following results were obtained:—



Strength of field, H, in C.G.S. units.	ω ampere.	$\frac{\omega}{H}$
3,200	0·0000510	150×10^{-10}
9,600	0·0001474	153×10^{-10}
14,930	0·0002087	140×10^{-10}
20,265	0·0002477	122×10^{-10}

It is seen that the ratio ω/H remains practically constant between 3,200 and 9,600, after which there is a rapid diminution with increase of strength of field.

In the case of bismuth, two leaves of different thicknesses were subjected to the same experiment. One was 0·045 mm., the other 0·005 mm. thick. The Hall-effect was approximately inversely proportional to the thickness. Other things being the same the intensity of the effect with bismuth is 5,735 times that with gold.

A series of experiments were made by varying the intensity of the current in the principal circuit, with the result that the effect is found to be approximately proportional to the current down to 0·04 ampere; but for lower intensities the effect is relatively greater. With discharge-currents the Hall-effect is of the same order of magnitude as with continuous currents. A. G.

2033. *Viscosity of Insulating Liquids in Electric Field.* **G. Pacher** and **L. Finazzi.** (N. Cimento, 11. pp. 290–294, April, 1900. Atti del R. Instituto Veneto di Scienze, 59. pp. 389–403.)—The times of flow of a certain quantity of a liquid through the space between two concentric cylinders are noted,

(1) when the liquids form the plates of a charged condenser, (2) when the cylinders are each at the same potential. With water, alcohol, ether, benzole, oil of turpentine, and bisulphide of carbon, there is no appreciable difference between the times; and hence there is practically no difference between the viscosities in the two states. This conclusion is different from the results obtained by Duff and Quincke. A. G.

2034. *A New Coherer.* **Jagadindu Ray.** (Calcutta Univ. Mag. 6. p. 102, Nov., 1899.)—Two magnetised rods are inserted, with unlike poles facing each other, in a block of cork or ebonite. A number of small rings of iron or steel wire connect two of the poles, and the other two form the terminals of the coherer. The current is adjusted until a slight touch produces a marked change of resistance. An incident electric wave causes a similar change, usually a diminution. Decoherence is brought about by tapping. The new coherer is well adapted for lecture experiments.

E. E. F.

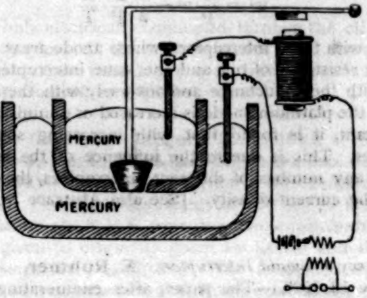
2035. *Spark-Length of Induction Coil.* **R. Beattie.** (Phil. Mag. 50. pp. 139–148, July, 1900.)—The object of the experiments here described was to examine how the length of the secondary spark depends upon the nature of the primary poles, the rate of break, and the E.M.F. in the primary circuit—(1) with no condenser across the break, (2) with condensers of various capacities across the break. Without the condenser the make-sparks were found to increase with the volts in primary with either platinum or carbon poles. The break-sparks, on the other hand, decreased considerably with platinum poles on increasing the volts in the primary; with carbon poles a slight decrease occurred for quick breaks, but an increase for a slow break. The primary current was always 2·5 amperes. It is noticeable that in certain cases the make-spark was larger than that due to break. The quicker the break the larger the spark in each case. With condensers the results are more complicated. For each kind of pole tried a most suitable capacity could be found which gave a maximum spark-length, this best capacity varying with the nature of the poles. The quickness of break of the several orders tried made no appreciable difference in the spark-length when the primary poles were of platinum; very little difference when they were of copper, but a considerable difference when they were of carbon or zinc. E. H. B.

2036. *Spectroscopy of Wehnelt Interrupter.* **E. Hoppe.** (Elektrotechn. Zeitschr. 21. pp. 507–508, June 21, 1900.)—The author observed that when a platinum wire is inserted in a tube containing mercury and used as negative electrode in a Wehnelt interrupter, the mercury is drawn through past the platinum wire when the current is started, unless the wire fits the orifice tightly. A spectroscope, focussed upon the liquid in the neighbourhood of the wire, shows the spectrum of mercury. By substituting solutions of metallic salts for the mercury other metallic spectra may be obtained. The author regards the drawing-through of the liquid as an electrodynamic phenomenon. E. E. F.

2037. *Wehnelt Interrupter on Alternate-Current Circuits.* **G. T. Hanchett.** (Elect. World and Engineer, 35. pp. 899–900, June 16, 1900.)—On an alternating-current circuit of 8,000 alternations per minute, the Wehnelt interrupter operates well, and produces some powerful and brilliant secondary effects. The secondary discharge is not of the striated character that obtains on direct-current work, and for short distances is yellow, fuzzy and calorific. For long distances it becomes crisp, blue, and snappy, the dividing-line between the two kinds of spark being quite abrupt. In some experiments, as the secondary terminals which were supporting the crisp blue spark were slowly approached there suddenly appeared at a striking distance of about three-quarters of an inch and coincidently with the blue spark a yellow calorific spark which was distinctly separate, and not until the discharge rods were very closely adjacent did the discharges unite with a single calorific spark. There is reason to believe these two discharges were respectively a positive and negative discharge occurring alternately, though to the eye simultaneous.

The interrupter action was quite violent, and the metal plate forming one terminal seemed to be attacked and quickly rendered the solution turbid. This was undoubtedly due to the effect of nascent oxygen, which was generated there to a much greater extent than in direct-current working. In general, it may be stated that the secondary discharges on alternating current Wehnelt interrupter circuits are not as brilliant and are of lesser voltage than in the case of direct currents. E. E. F.

2038. *New Mercury Interrupter.* **E. W. Caldwell.** (Elect. Rev. N.Y. 36. p. 631, June 20, 1900.)—The interruptions are made between two surfaces of mercury instead of between mercury and another metal. Hence surface impurities are avoided, and any mercury vapour formed is recondensed at once.



The construction is shown in the diagram. The separation of the two mercury surfaces is effected by a sort of poppet valve of insulating material driven by an electromagnet in the same circuit. The difficulty lies in obtaining a material which is not destroyed by the sparks. The author suggests lava. E. E. F.

2039. *Resistance of Wehnelt Interrupter.* **C. Heinke.** (Phys. Zeitschr. 1. pp. 334–336, April 28, 1900.)—Commenting on the paper referred to in the following Abstract, the author points out that the Wehnelt interrupter is a "wave-current generator" of the second class, whose resistance varies rapidly within wide limits. In introducing, for practical purposes of calculation, the conception of a mean value, it is necessary to define that conception very accurately. In the Wehnelt interrupter, three different kinds of resistance may be distinguished. The first is the ordinary ohmic resistance. The second is the effective resistance as calculated from the watts consumed and the effective current intensity. These two kinds are not equal, since the instantaneous values of the current strength and the resistance always change in opposite senses. The third kind of resistance is obtained by dividing the effective E.M.F. between the terminals of the interrupter by the effective current. The quantity denoted by w in Ruhmer's paper is not identical with any of the above resistances, since the effective E.M.F. is not measured at the terminals of the interrupter, but of the interrupter and inductance combined. The two quantities denoted by w in the first and second equation above are therefore not identical. None of the three resistances as defined are constant in the Wehnelt interrupter, as may be proved by measurements with a wattmeter or a calorimeter. E. E. F.

2040. *Resistance of Wehnelt Interrupter.* **E. Ruhmer.** (Phys. Zeitschr. 1. pp. 303–305, April 7, 1900.)—The author investigates the validity of Simon's formula for the period T of a Wehnelt interrupter in terms of the inductance L, the resistance w, and the E.M.F., E., viz. :—

$$T = \frac{3}{2}\frac{L}{w} + \frac{Cw}{E^2}$$

which, combined with Simon's second relation

$$J^2wT = C,$$

gives the following equation for the mean resistance regarded as constant,

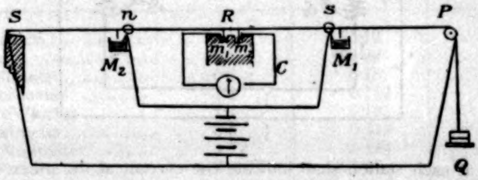
$$w^3 = \frac{E^2}{J^2}w - \frac{3}{2}\frac{E^2}{J^2}\frac{L}{T}$$

Experiments with three interrupters, whose anode areas were as 1 : 2 : 3, showed that the resistance of one and the same interrupter is not constant, but increases with the inductance and inversely with the current strength. If the surface of the platinum anode is increased or diminished, leaving everything else constant, it is found that with increasing surface the current density decreases. This is due to the influence of the inductance, which ensures that in any number of different interrupters, the frequency solely depends upon the current density. [See also Abstract No. 164 (1900).] E. E. F.

2041. *Frequency of Liquid Interrupters.* **E. Ruhmer.** (Phys. Zeitschr. 1. pp. 345–347, May 12, 1900.)—The paper, after enumerating methods which have been used for measuring the frequency of the interruptions, describes a dust figure method. A wire hook rests on a brass disc covered with paper which has been treated with shellac and sprinkled with lycopodium. This disc is rotated by clockwork. The hook describes a spiral curve in which dust-heaps occur at every current interruption, the hook being connected with the positive pole of the interrupter and the rotating axle with the negative pole. The interruptions per second are found by means of a speed counter. Photographs of the disc are reproduced, showing well-marked dust-heaps. G. E. A.

2042. *Mechanical Model of a Condenser.* **V. Karpen.** (Soc. Franç. Phys., Bull. 150. pp. 3–4, June 1, 1900.)—Each plate of the condenser is represented by a combination of two wheels gearing into a pinion in such a way that the rotation of the pinion corresponds to the charge of the plate, while the rotations of the wheels correspond to the charges of its faces. The dielectric is represented by springs which are strained by the rotation of the wheels. Thus the model illustrates the strain set up in the dielectric of a condenser when the condenser is charged and the manner in which the strain is removed during discharge, the discharge being oscillatory if the moments of inertia of the movable parts be large as compared with the frictional resistances. It also illustrates the disruptive discharge, the slow discharge and the residual charge of a condenser. The expression for the energy stored up in it, when " charged," is of the same form as that for the energy stored up in a condenser. W. E. T.

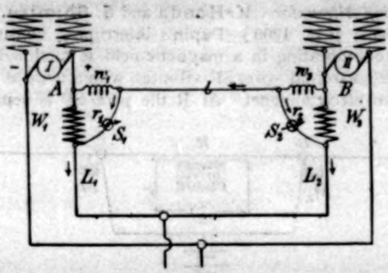
2043. *A String Alternator.* **K. Honda** and **S. Shimizu.** (Amer. Journ. Sci. 10. pp. 64–65, July, 1900.)—Pupin's interrupter, consisting of a wire carrying a current vibrating in a magnetic field, is modified to serve as an alternator. The horizontal wire, SP, vibrates, with a node at R, between the poles *n*, *s*, of an electromagnet. At R the wire SP is separated into two parts, which are only electrically connected through the circuit C. M_1, M_2, m_1, m_2 are mercury cups. If the tension be not small the actual frequency does not differ by more than 1 per cent. from the calculated value, the vibrations ranging from 30 to 1,000 per second. G. E. A.



2044. *Standard Cells.* **W. Jaeger.** (Centralblatt f. Accumulatoren- u. Elementenk. pp. 3–5, Jan. 1; 28–32, Jan. 15; 51–56, Feb. 1; 73–76, Feb. 15; 89–92, March 1, 1900.)—These papers form a short treatise on the subject of primary batteries. The thermodynamics of the cell is first dealt with, the method of calculating the E.M.F. from the heat equivalents of the chemical reactions being given as originally given by Kelvin and then modified by Helmholtz for temperature coefficient. The conditions which a cell must fulfil in order to be a standard of E.M.F. are next considered, and then the different primary batteries are reviewed in the light of these conditions. The Clark and the cadmium cell are the only two which can be regarded as at all standard, and the latter has the great advantages of a very low temperature coefficient and no temperature lag. Full instructions for setting up these cells are given. The cadmium cell as made and patented by Weston contains a solution of cadmium sulphate which is saturated at 4° C. J. B. H.

2045. *Indicating Currents at a Distance.* **C. Michalke** and **O. Martienssen.** (Elektrotechn. Zeitschr. 21. pp. 461–463, June 7, 1900.)—This device is for use in cases where one network is fed by two generating stations arranged at some distance apart, so as to enable it to be determined, at either station, what current is being supplied to the mains at the other station, or for indicating the E.M.F. of distant batteries of constant internal resistance, independently of the magnitude and direction of the charging or discharging current.

This is effected by means of one conductor connecting, *e.g.*, the positive poles of the two stations. After describing two arrangements whereby this can be effected, which arrangements, however, do not give the desired result directly, the authors give the arrangement shown in the figure where J_1 is the current in the conductor L_1, the resistance of which, including the measuring resistance W_1, is R_1; J_2, the current in the conductor L_2, the resistance of which, including the measuring resistance W_2, is R_2; i the current in the conductor l; i_1 that in the resistance w_1; i_2 that in the resistance w_2: c_1 that in the current-indicator S_1; and c_2 that in the current-indicator S_2; r_1 and r_2 are the resistances of the current-indicators S_1, S_2. In order that the current-indicator at each station shall indicate the current at the other station, the following conditions must be satisfied, viz. :—



$$J_1\,W_1 + i_1\,w_1 = 0,\ i.e.,\ J_1 : - i_1 = w : R_1$$

assuming that the resistances R_1 and R_2 are negligible relatively to the resistance w, which is the resistance of l from A to B. Thus $w_1 = w\frac{W_1}{R_1}$ and $w_2 = w\frac{W_2}{R_2}$. The constants of the current-indicators are obtained from the equations—

$$c_1 = J_2\frac{R_2}{R_1}\cdot\frac{W_1}{r_1 + w_1}$$

$$c_2 = J_1\frac{R_1}{R_2}\cdot\frac{W_2}{r_2 + w_2}.$$

The conditions for the cases where R_1 R_2 are not negligible and equations for calculating the values of the various resistances are also given, together with a numerical example. C. K. F.

2046. *Commercial Electrical Measuring-Instruments.* **E. S. Shoults.** (Northern Soc. Elect. Engin., Proc. 5. pp. 81–61; Discussion, pp. 61–68, 1899.)—In this paper the author discusses the various forms of commercial instruments on the market. He first deprecates the use of dials of a larger size than 9 inches as he considers that errors due to weight, inertia, and friction become excessive when this size is exceeded. As regards the influence of stray magnetic fields, he finds that instruments of the D'Arsonval type, when enclosed in stout iron cases, are not affected under ordinary conditions. He has obtained very satisfactory results from instruments fitted with the McWhirter shielding device [see Abstract No. 521 (1898)], which consists in replacing the brass cheeks of the main coil of any ordinary electromagnetic instrument by cheeks of iron about $\frac{1}{4}$ inch thick, and then slipping over the whole bobbin a tube of iron of like thickness. In one instrument the disturbing effect was reduced from 16 per cent. to 5·9 per cent., and in another from 30 per cent. to 0·75 per cent. The errors introduced by residual magnetism are very small and may be neglected in practice. A Stanley movement was also made using hardened tool steel in place of soft iron, and the results showed that at 70° deflection, the maximum percentage difference between the rising and falling curves was only 1·7 per cent. As regards accuracy, the author pointed out that large temperature errors existed in D'Arsonval type permanent magnet ammeters, having moving coils wound with copper and shunts of some alloy which does not vary in resistance with changes of temperature. Results are given of some experiments made to determine the forces dealt with in certain well-known types of instrument, as follows:—

Type of Instrument.	Watts used in active part.	Torque per watt in grammes at 1 cm. radius.	Deflection in degrees.
Kelvin Balance	70·9	25·19	—
„ Gauge	6·4	0·295	45
Dolivo Voltmeter	0·8	0·187	75
Stanley Voltmeter	1·4	0·139	72
Stanley-McWhirter	1·4	0·195	72
Nalder Voltmeter	0·6	0·415	70
Evershed Voltmeter	1·17	0·184	78
Western Pattern	0·0012	472·00	84

The author also describes an instrument made by the General Electric Company, which can be used either as an ammeter, a voltmeter, or a galvanometer. It consists of a moving coil galvanometer which, when used as a voltmeter, has an external resistance of manganin in series with the moving coil; and when used as an ammeter has a shunt arranged so that the current passes through it, the instrument indicating the fall of potential over this shunt. In discussing alternate-current instruments, the author stated that he found that a shielded bobbin is quite as good as a plain one, provided that the iron is worked at a low induction density and is laminated. An ohmmeter made by the General Electric Company was also described. This instrument consists of a low reading ammeter, arranged so that it can be connected by means of a switch, through a known resistance between either pole of the circuit and earth. As most circuits work at constant voltage, the deflection obtained will be inversely proportional to the earth resistance under test. The new Aron meter is described [see Abstract No. 1954 (1899)]. C. K. F.

2047. *Universal Galvanometer.* **F. Breisig.** (Elektrotechn. Zeitschr. 21. pp. 538–540, June 28, 1900. Paper read before the Elektrotechnische Verein, May 22, 1900.)—The instrument is intended for testing purposes at telegraph stations as a universal galvanometer. It is an improved form of the Siemens apparatus. The circular slate disc, with its peripheral slide-wire, is retained, but the astatic differential arrangement is replaced by differential suspended coils. There is also a very compact scheme of plugs and switches for changing connections for the various tests. A general view of the instrument is given, and a diagram and description of the connections.

R. A.

ALTERNATING CURRENTS AND MAGNETISM.

2048. *Transmission of Polyphase Currents over Long Lines.* **C. E. Guye.** (Archives des Sciences, 9. pp. 532–552, June, 1900.)—A mathematical paper in which the author considers the generalised meanings of the terms "inductance" and "capacity" per unit length of line [see Abstract No. 1308 (1900)], taking first the case of electrostatic equilibrium, then that of steady currents traversing the conductors, and finally that of variable currents. The second part of the paper deals with the case of a symmetrical system of conductors traversed by polyphase currents. A. H.

2049. *Action of Light on Magnetism.* **J. H. Hart.** (Amer. Journ. Sci. 10. pp. 66–73, July, 1900.)—Iron bars prepared by Bidwell's method (Proc. Phys. Soc., London, April, 1889, p. 455) are used, first in verifying Bidwell's experiments. Placed in a field of 400 c.g.s., the bars were kept free from vibration as the magnetising force was withdrawn, and then exposed to the light from an ordinary gas-jet at 6 inches' distance. In every case a decrease of magnetism was observed. The action is concluded to be in general a purely mechanical one, similar to the effect of a blow. Experiments with iron films on glass showed a probable action of polarised light. G. E. A.

2050. *Magnetic Hysteresis in a Rotating Body.* **A. Dina.** (Elettricità, Milan, 19. pp. 324–326, May 26, 1900. Paper read before the R. Istituto Lombardo di Scienze e Lettere, March 29, and April 5.)—Experiments were made to compare the hysteresis loss in a rotating mass of iron with that produced by alternate currents, and by step-by-step cycles. A coil of insulated iron wire was arranged to rotate in the field of a dynamo, and the rise of temperature caused by the heat evolved was found by the increase of resistance of the coil as measured on a Wheatstone bridge. The amount of energy corresponding to a given rise of temperature was determined by observing the latter when a steady current was sent through the coil. The induction was varied from 7,000 to 18,000. Comparing the hysteresis loss thus measured with that found by step-by-step cycles, the former was slightly greater up to $B = 10{,}000$, and then became less, showing at $B = 18{,}000$ a difference of about 9 per cent. This difference agrees with results predicted by Swinburne and Ewing from the molecular theory of magnetism. G. H. B.

REFERENCES.

2051. *Electric Units.* **E. Budde.** (Elect. World and Engineer, 35. pp. 628–629, April 28, 1900.)—With reference to the proposed changes in the system of legalised electromagnetic units [see Abstracts Nos. 1055 and 1056 (1900)] the author objects to such changes on account of commercial and legislative objections. E. E. F.

2052. *Measurement of Phase Differences.* **F. Fontaine.** (Assoc. Ing. Él. Liège, Bull. 11. pp. 51–83, April 20, 1900.)—This is a very complete *résumé* of all known methods of determining the difference of phase between two alternating currents, or between an alternating potential difference and the resulting current in any circuit. The methods dealt with are those of Janet, Puluy, Ferraris, Engelmeyer, Korda, Hess, Arnò, Dobrowolsky, Blakesley, Claude, and Brüger. W. G. R.

2053. *Treatment of Urethral Stricture by Electrolysis.* **F. Lynch.** (Archiv. d'Él. Médicale, 8. pp. 203–205, May, 1900.)—The author reports four cases cured in this way. H. L. J.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

2054. *Solubility of Hydrated Mixed Crystals*, III. **W. Stortenbeker.** (Zeitschr. Phys. Chem. 34. pp. 108–123, July 3, 1900.)—A continuation of previous work on the subject (Zeitschr. Phys. Chem. 17. 643, 1895, and 22. 60, 1897.)—In the present paper it is shown that the mixed crystals of copper-zinc sulphate and of copper-manganese sulphate consist of concentric layers of different composition, the outer layers being richer in copper than the inner. The question is theoretically discussed, and it is concluded that this peculiarity is probably common to all mixed crystals, although the fact can only be definitely proved in favourable cases. N. L.

2055. *Allotropic Forms of Selenium.* **A. P. Saunders.** (Journ. Phys. Chem. 4. pp. 423–518, June, 1900.)—Attempts were made to discover the existence of transition-points between the various modifications of selenium. It was found, however, that the amorphous or vitreous (supercooled liquid) modification (sp. gr. = 4·27) is labile at all temperatures and tends to pass into the stable crystalline grey or metallic variety (sp. gr. = 4·80), although the transformation does not readily occur below 60° or 80°. In contact with certain solvents, however, the amorphous selenium is transformed into the metallic form at ordinary temperatures.

A third modification of selenium is the red crystalline variety (sp. gr. = 4·47), which appears to be intermediate between the two preceding forms. It is produced by the action of certain solvents on the amorphous form and probably has an instable melting-point at 170–180°, when it melts and immediately solidifies in the metallic form. Selenium appears, therefore, to be a monotropic dimorphous substance, like benzophenone, but possessing in addition the property of supercooling until the liquid becomes a vitreous mass with very little tendency to pass into the stable solid modifications.

The paper consists largely of a very full summary of the results of other workers on the physical properties of the different modifications of selenium and contains a bibliography of the subject. T. M. L.

2056. *Heat of Solution of Hydrogen Peroxide.* **de Forcrand.** (Comptes Rendus, 130. pp. 1620–1622, June 11, 1900.)—The author prepares hydrogen peroxide solutions of various strengths by the methods described by Hanriot and Wolffenstein, and determines their heats of dilution with the following results (final state = H_2O_2 + 3 litres H_2O) :—

Percentage of H_2O_2.	Initial State.	Heat of Dilution (Cal.).
35·31	H_2O_2 + 3·46 H_2O	+ 0·071
42·66	„ + 2·53 „	+ 0·093
55·16	„ + 1·54 „	+ 0·099
65·38	„ + 1 „	+ 0·310
85·93	„ + 0·3 „	+ 0·403

On plotting these results the author finds that the curve so obtained comprises two chief portions, namely from 0 to 55·16 per cent., and from 65·38 to 100 per cent., the intermediate part rising steeply and pointing to the existence of a hydrate of the formula $H_2O_2 + H_2O$. By graphically extrapolating from the above curve the heat of solution of anhydrous peroxide is found to be + 0·46 Cal. The paper concludes with calculations of the "mean thermal value" of the hydroxyl group, and of the influence exerted on it by C, CH_2, and CH_3, whereby the author hopes to lay the foundations of a theory of acidity. Reference must, however, be made to the original paper for the details of this calculation. F. G. D.

2057. *Heat of Formation of Alloys.* **J. B. Tayler.** (Phil. Mag. 50. pp. 37–43, July, 1900. Read before the Phys. Soc. of London.)—The heat of formation is here determined by measuring the heat of solution in mercury (*a*) of the alloy, and (*b*) of its constituents, and assuming that the products in the two cases are similar. Alloys of lead with tin, bismuth and zinc, and of zinc with tin and mercury were used.

The experimental results are given in tabular form in the paper, and some of them are given below. It is evident from the second column that the alloys contain a small percentage of true compounds, and it may be noted that eutectic alloys (*i.e.*, alloys with lowest melting-point) do not necessarily correspond to the greatest evolution of heat.

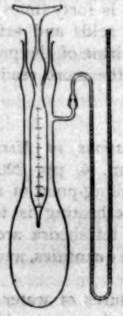
ALLOY.	Heat of Formation per gramme alloy in calories.	Heat of Formation per gramme molec. weight of compound in calories.	Volts corresponding thereto.	Observed Volta Effect in volts.	Peltier E.M.F. in volts.
Lead-Zinc Eutectic. Zinc 1·6 p.c.	−5·8	−23,800	0·53	0·210 (Ayrton & Perry)	0·0008
Lead-Zinc. Zinc 28·9 p.c.	−3·5	−960	0·02	0·31 (Pellat)	
Lead-Bismuth. Lead 55·6 p.c.	+3·8	+1,400	0·03	...	0·017
Tin-Zinc Eutectic. Zinc 8·3 p.c.	+6·1	+4,800	0·10	0·281 (A. & P.) 0·35 (Pellat)	0·0009
Lead-Tin.					
Tin 90·0 p.c.	+3·9	+8,100	0·18	0·099 (A. & P.)	0·0000
„ 61·8 „ (Eutectic)	+1·9	+1,000	0·02	0·04 Pellat by difference.	
„ 21·0 „	−0·8	−450	0·01	scratched	
„ 5·0 „	−1·1	−2,600	0·06	0·10	
„ 2·0 „	−1·0	−6,500	0·14	clean.	

J. B. H.

2058. *Determination of Transition Temperatures.* **H. M. Dawson** and **P. Williams.** (Journ. Phys. Chem. 4. pp. 370–382, May, 1900.)—Transition temperatures have been investigated by the identity method (*i.e.*, the obtaining of identical saturated solutions of two systems transformable into each other), in which the concentration, the vapour-pressure, the solution-pressure, and the difference of potential between the solution and a reversible electrode have severally been taken as the property defining the identity. The authors now propose to use (1) the density, (2) the electrical conductivity, as such defining properties. By the former they find 32·38° and 59° C. as the transition temperatures for Glauber's salt and manganous chloride respectively, the thermometric method giving 32·379° and 57·9°; the latter method gives 32·5° for Glauber's salt, for which, however, it is not a sensitive method, though it is markedly sensitive for thorium sulphate, for which it indicates 48° C. as the transition-temperature. Since this value differs considerably from 43°, the transition-temperature found by Roozeboom by the solubility method, the authors tested their result by the dilatometer and vapour-density methods, which gave 46·5° and 47·8° respectively. [See also Abstract No. 240 (1900).]

R. E. B.

2059. *Gasometric Apparatus.* **Job.** (Journ. de Physique, 9. pp. 347–349, June, 1900.)—This apparatus is for the purpose of determining the volume of gas absorbed or liberated in a chemical reaction between two bodies, one of which is a liquid. It consists, as will be seen from the accompanying figure, of a glass bulb provided with a manometer in the form of a long, thin tube open at the end and containing mercury or other liquid. In the neck of the bulb fits a ground hollow stopper, which is prolonged so as to form a graduated burette, and is closed by means of a ground stopper fitting in the narrow part. This ground stopper is also hollow, and is provided, as is also the part of the pipette in which it fits, with a small hole. When the pipette is full of liquid and closed by the stopper the liquid does not flow out until the two small holes are brought into juxtaposition. After the experiment the excess of pressure is read off at the same temperature at which the apparatus was closed. The arrangement may be used in estimating calcium carbide by the evolution of acetylene and in other similar determinations and also in the study of equilibrium phenomena between a liquid and a gaseous phase.



T. H. P.

2060. *Velocity of Formation of Olefines from Aliphatic Iodides.* **S. Brussoff.** (Zeitschr. Phys. Chem. 34. pp. 129–148, July 17, 1900.)—Mainly of chemical interest. The velocity of formation from the chlorides, bromides, and iodides increases in the order indicated, and depends greatly on the number of side-chains and their distance from the halogen atom. N. L.

2061. *Pseudo-Equilibria.* **L. Marchis.** (Journ. de Physique, 9. pp. 326–339, June, 1900.)—The author gives an elementary account, free from mathematical considerations, of the theory of chemical pseudo-equilibria propounded by Duhem. The paper is illustrated by diagrams, and reference is made to the work of Pelabon on the system H—Se, of Jouniaux on the system H—Ag—Cl, of Gautier and Hélier on the system H—O, and of Joubert on the system P—O. Only a very brief reference is made to Bodenstein's work (Zeit. Phys. Chem. 1899), and no attempt is made to refute his arguments. [See Abstracts Nos. 233 and 234 (1900).] F. G. D.

2062. *Taste and Ionisation of Acid Salts.* **L. Kahlenberg.** (Journ. Phys. Chem. 4. pp. 533–537, June, 1900.)—The fact that the sour taste of acid sodium salts is much more intense than it ought to be according to the assumption that sourness is caused by hydrogen ions only, has been explained by Richards as due to the removal of hydrogen ions by the act of tasting, more ions being then formed and removed and so on; the intensity of the sour taste is thus due to a cumulative effect. The author points out, however, that with an acid like hydrochloric acid a certain minimum initial concentration of hydrogen ions is necessary in order that a sour taste may be experienced, this concentration being slightly greater than N/1000. But in the case of acid sodium malate a solution with only one-fortieth of this concentration of hydrogen ions has a sour taste, and it can hardly be supposed that the organs of taste are capable of storing up hydrogen ions from weak acids or acid salts until their concentration is forty times the original. The author concludes that the sour taste of acids and acid salts is due to the chemical reactiveness they possess by virtue of the presence of hydrogen replaceable by a metal or basic radicle; the more readily this hydrogen is replaceable the more intense is the taste. T. H. P.

2063. *Vapour-Pressure Relations in Mixtures of Two Liquids.* **A. E. Taylor.** (Journ. Phys. Chem. 4. pp. 290–305, April, and 355–369, May, 1900.)—In determining the boiling-point of mixtures of liquids special precautions are necessary if superheating is to be avoided. Garnets mixed with platinum or with silver tetrahedra are especially effective, but even these must be added in large quantities, and their volume must be at least half that of the liquid used.

The boiling-points of mixtures of water and acetone in different proportions have been investigated over a wide range of pressures, and the composition of the distillate from nine different mixtures has been determined at two different pressures. The results are given in tables and are represented graphically by means of p-T curves for the series of mixtures, as well as by isotherms and isobars. T. M. L.

2064. *Thermodynamics of Normal Elements.* **E. Cohen.** (Zeitschr. Phys. Chem. 34. pp. 62–68, July 3, 1900.)—In calculating the E.M.F. of a Clark cell from the thermo-chemical data and the temperature coefficient of the cell, it is not sufficient merely to allow for the displacement of mercury by zinc in the sulphate, for the zinc sulphate separates from the saturated solution with $7H_2O$. It is now shown that a further correction is needed to allow for the fact that the $7H_2O$ is taken from a saturated solution and causes the separation of a larger quantity of zinc sulphate than that which is formed by the dissolving of the zinc. The heat change calculated from the electrical data is 81,490 cal. The displacement of mercury by zinc represents 55,090 cal., or, when corrected for the separation of the zinc sulphate as $ZnSO_4 . 7H_2O$, 77,780 cal.; and the correction now made for the removal of water from the solution and separation of a further quantity of zinc sulphate brings the value up to 81,127 cal., a value which agrees very closely with that calculated from the E.M.F. of the cell. Similar considerations apply to the hydrate $ZnSO_4 . 6H_2O$, which is stable above 39° C. T. M. L.

2065. *The Weston Cell as a Transition Cell and as a Standard of E.M.F.* **H. T. Barnes.** (Journ. Phys. Chem. 4. pp. 339–348, May, 1900.)—Kohnstamm and Cohen [see Abstract No. 1059 (1898)] have shown by means of solubility-determinations and other methods that an inversion-point occurs at 15° in the temperature curve of cadmium sulphate, and this is now used to explain the irregular behaviour of the Weston cell observed by Jaeger and Wachsmuth (Wied. Ann. 59, 575, 1896). Between 15° and 40° C. the E.M.F. of a number of cells was found to be accurately represented by the formula $E_t = E_{15} - 0{\cdot}086\ (t - 15^\circ)$, but below 15° each cell shows a different temperature coefficient, depending on the rate at which the transformation takes place. In two cells the curve above 15° was continued on cooling below that temperature to about 2°, when a rapid change from the labile to the stable form took place.

The ratio $\frac{\text{Clark } 15^\circ}{\text{Cadmium } 20^\circ}$ was found to be 1·40658, a result practically identical with the recent value, 1·40663, determined by Kahle (Wied. Ann. 67, 35, 1899). T. M. L.

2066. *Ionisation Constant of Azoimide (Hydrazoic Acid).* **C. A. West.** (Chem. Soc., Journ. 77. and 78. pp. 705–707, May, 1900.)—For sodium hydrazoate, μ_∞ has the value 109, whence the value for hydrazoic acid is 385. Conductivity measurements with the acid give the following results:—

v	μ	m	k
10	5·38	0·01397	0·0000198
100	15·98	0·0415	0·0000180
1000	45·97	0·1194	0·0000166

From the rate of inversion of cane-sugar by the acid the value of k is found to be 0·0000186. The avidity of hydrazoic acid is hence slightly greater than that of acetic acid ($k = 0{\cdot}0000180$). T. H. P.

2067. *Formation of Ozone by the Brush Discharge in Oxygen.* **E. Warburg.** (Preuss. Akad. Wiss. Berlin, Sitzb. 33. and 34. pp. 712–721, July 5, 1900.)—The author supposes that the brush discharge besides having an ozonising effect on oxygen has a deozonising effect on ozone, and this combined with the small spontaneous deozonising effect controls the percentage of ozone which can be obtained in oxygen by the brush discharge. Supposing that the ozonising and deozonising effects are proportional respectively to the number of gramme molecules of oxygen (n_2) and of ozone (n_1) present in the mixture, the increase in the number of molecules of ozone is given by—

$$dn_1 = b \,.\, \frac{n_2}{v}\, dt - (a + a')\, \frac{n_1}{v}\, dt,$$

where a, a' and b are constants, and v the volume of the vessel. The constant "a" refers to the deozonising effect of the discharge, and "a'" to the spontaneous deozonisation; "a'" is found to be very small compared with "a." The latter is found to vary very considerably with temperature, being three times as great at 93° as it is at 0° C. The constant b is very little affected by temperature, so that as the temperature increases the ozonising effect of the discharge remains constant, while the deozonising effect increases very rapidly, thus diminishing the percentage of ozone present.

The value of "*b*" for the negative discharge is almost three times as great as it is for the positive discharge, while the value of "*a*" is nearly the same for both. The temperature influence is also approximately the same for both.

J. B. H.

2068. *Electro-chemical Equivalent of Carbon.* **S. Skinner.** (Cambridge Phil. Soc., Proc. 10. pp. 261–267, May 7, 1900.)—The author electrolysed potassium permanganate, using a carbon anode. The gas evolved contained carbon dioxide in quantities varying from 77 to 86 per cent. The permanganic acid appears to be chiefly reformed. In the case of electrolysis of water, sulphuric acid, and potassium permanganate, with a carbon anode, the author suggests that the primary products are $C(OH)_4$, $C(HSO_4)_4$, and $C(MnO_4)_4$ respectively.

W. R. C.

2069. *Electrolytic Determinations and Separations.* **L. G. Kollock.** (Chem. News, 81. pp. 220–222, May 11; 231–233, May 18; 244–246, May 25; and pp. 271–273, June 8, 1900. From the Amer. Chem. Soc., Journ. 21. No. 10.)—In this paper, which does not admit of suitable abstraction, the author gives the results of an extensive series of experiments made to determine the conditions as regards current density, voltage, &c., under which cadmium, silver, mercury, gold, copper, bismuth, and iron may be estimated electrolytically both in pure solutions and when mixed with other metals.

T. H. P.

2070. *Electrolytic Deposition of Metals from Non-Aqueous Solutions.* **L. Kahlenberg.** (Journ. Phys. Chem. 4. pp. 349–354, May, 1900.)—In connection with previous researches on the potential differences between metals and non-aqueous solutions of their salts [see Abstract No. 545 (1900)] it was necessary to ascertain whether Faraday's law held for such solutions, and a series of electrolytic determinations were made with solutions of silver nitrate in pyridine, aniline, benzonitrile, quinoline, and acetone, of lead nitrate in pyridine, and of antimony chloride in methyl alcohol. The electrolyses were carried out at about 20° between a platinum kathode and an anode of the same metal whose salt the solutions contained, and the amount of metal deposited was compared with that deposited in a silver voltameter in circuit. Apart from minor discrepancies due to secondary reactions, Faraday's law was found to hold.

A compact deposit of silver may also be obtained from a pyridine solution using two platinum electrodes; the E.M.F. should be about 3 volts and the kathode current density about 0·3 ampere per 100 sq. cms. Under certain conditions, moreover, good results are obtained from solutions of silver nitrate in mixtures of water with pyridine, aniline, or acetone. N. L.

2071. *Electrolysis of Sodium Chloride.* **C. G. L. Wolf.** (Journ. Phys. Chem. 4. pp. 200–206, March, 1900.)—An apparatus is described which permits of variation of conditions as quickly as possible, and with a minimum of rearrangement; it is well adapted for lecture demonstrations, and the effect of adding alkalies, acids, or salts may be shown without interrupting the current. It consists of a U-tube having a central limb for the insertion of a stirring apparatus, each of the two side limbs being fitted with a thermometer, a platinum electrode, and a tube for conveying the gases evolved to a measuring tube. A diagram is given in the paper. Details are also given of the electrolysis in this apparatus of a solution containing 300 grammes of sodium chloride, and 1·8 grammes of potassium chromate per litre, using a current of about 1 ampere, the anode and kathode current densities being respectively 0·14 and 6·66 amperes per sq. cm. Under these conditions the average efficiency was about 80 per cent., and in a little over seven hours 12·7 per cent. of the sodium chloride was oxidised to chlorate. Stress is laid on the importance of efficient stirring, and the maintenance of a constant temperature if a high efficiency is to be attained. N. L.

2072. *Electrolytic Preparation of Fluorine in a Copper Vessel.* **H. Moissan.** (Chem. News, 81. p. 218, May 11, 1900; from the Soc. Chim., Bull. 23. No. 8).—When a platinum cell is used for the electrolysis of a hydrofluoric acid solution of potassium, the rapid wearing away of both the cell and the electrodes makes the apparatus very expensive. To determine whether it is possible to replace the platinum by another metal, the author placed samples of various metallic wires at the bottom of the electrolytic vessel, the preparation of fluorine being then carried out as usual. It is found that of all metals, with the exception of platinum, copper is the least attacked under these conditions. An electrolytic cell of copper for the preparation of fluorine gives good results, but the electrodes must be of platinum; the copper probably becomes coated with a layer of insoluble badly conducting copper fluoride, and in the case of the electrodes such a deposit would greatly diminish or even stop the current. T. H. P.

2073. *Electrolysis of Nitrogen Hydrides and Hydroxylamine.* **E. C. Szarvasy.** (Chem. Soc., Journ. 77. and 78. pp. 603–608, May, 1900.)—A preliminary account of experiments on the electrolysis of ammonia, hydrazine, azoimide, and hydroxylamine and their salts at different current densities, temperatures, and concentrations. The three nitrogen hydrides were found to yield their nitrogen and hydrogen in the theoretical proportions, when sufficiently high current densities were employed, even at the ordinary temperature. Attempts to electrolyse hydroxylamine were unsuccessful, owing to spontaneous decomposition occurring; when hydroxylamine sulphate is used, secondary reactions take place, ammonia being formed at the kathode and oxygen compounds of nitrogen at the anode. N. L.

2074. *Progress of Aluminium.* **J. W. Richards.** (Frank. Inst., Journ. 149. pp. 451–459, June, 1900.)—A summarised version of an address delivered on April 18, 1900. Referring to the question of cost, the lecturer stated that every item of manufacture had been reduced since the introduction of the electrolytic process. The *lowest* cost per lb. is now probably about 20 cents, while the selling price is 25 cents in Europe and 30 cents in U.S.A. Details of the latest methods of production cannot be given, owing to the reluctance of manufacturers to publish them. As evidence of the comparative cheapness of aluminium, the lecturer stated that 1 dozen thimbles of the new metal could be bought in Philadelphia for 5 cents. The metal in these weighs only ⅓ oz., and would cost the manufacturer of the thimbles about 1 cent. The present comparative cost for *equal volumes* of the following metals were :—

Aluminium (⅓ lb.)	11 cents.
Brass (1 lb.)	15 cents.
Copper (1 lb.)	17 cents.
Tin	30 cents.

Five per cent. copper, nickel or manganese or 30 per cent. zinc, added to aluminium yielded strong light alloys.

The Delaware Metal Refining Company of Philadelphia are producing an alloy of sp. gr. 8·1, as rigid and strong as ordinary bronze or gun metal.

Referring to the use of aluminium for cooking-vessels, the lecturer stated that an aluminium kettle had been in use in his home for seven years, and beyond an internal brown coating of oxide which seemed to protect the metal beneath, it had not suffered any change by continuous use. In America aluminium is superseding zinc for fruit-jar caps, as, though more expensive, it is less harmful if acted on by the fruit-juice.

As regards the use of aluminium for lithographic printing, the author stated that thirty firms in U.S.A., and about forty-five in Europe are already using the new metal, chiefly on rotary presses, and a great development may be looked for in this direction.

The use of aluminium for electrical purposes is progressing rapidly. In 1899, 500 tons of aluminium in wire or rod form had been used for long-distance transmission, or for trolley lines in U.S.A.

The new metal can be beaten out into leaf only $\frac{1}{100000}$ inch in thickness, and this leaf had entirely displaced silver-leaf in decoration work. The leaf can also be ground to a powder, and used either for printing or painting when mixed with a suitable vehicle.

The lecturer closed his address with a reference to the use of aluminium for reducing purposes. Tissier, and Wahl and Greene, had first experimented with granulated and powdered aluminium for this purpose ; and the latter two experimenters obtained chromium and manganese free from carbon in this way. Goldschmidt had introduced improvements in this process of reduction, and his method is now in use at Essen, in Germany, and at Philadelphia, for production of ferro-chromium and ferro-manganese. These alloys are used in the manufacture of armour-plate steel. J. B. C. K.

REFERENCE.

2075. *Electro-chemistry.* **F. M. Perkin.** (Nature, 62. pp. 138–139, June 7, 1900.)—An article describing the progress in obtaining the non-metals and their compounds, and organic products, by electrolytic methods. Among the former, hydrogen, oxygen, ozone, artificial diamonds (Majorana's process), carborudum, the alkalies, bleaching powder, hypochlorites, chlorates, and white lead, are very briefly dealt with. Among organic compounds, iodoform, chloral, and aniline and its oxidation products are touched upon. The article closes with a brief description of the electrolytic method for printing aniline-black and indigo-blue patterns upon cloth, and with a plea for greater attention to the study of electro-chemistry by chemists in this country. J. B. C. K

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

2076. *Steam Turbines and Superheated Steam.* **R. H. Thurston.** (Science, 11. pp. 972–973, June 29, 1900.)—It is found that there is a considerable gain in both the efficiency and capacity of a steam turbine by the use of superheated steam. This is contrary to expectation, since the internal surfaces of a steam turbine are in a steady state and not subject to alterations of temperature such as must obtain in all cylinder and piston engines. There is consequently none of the usual initial condensation loss, and it is chiefly to reduce the waste from this cause that superheated steam is employed with ordinary engines. With the steam turbine the only advantage to be expected is the small increase of thermodynamic efficiency due to the augmented range of temperature. In some experiments on a 10-H.P. Laval turbine at Sibley College, this gain would amount theoretically to about one-tenth of 1 per cent. for each 3° F. of superheat, whereas the actual results give a gain of 1 per cent. in efficiency for each 3° F., and a doubling of the capacity of the machine by the use of superheat through 37° F. The gain in efficiency is substantially proportional to the amount of superheat, and seems to be due to the elimination of the loss by friction caused by moisture in the steam as it passes through the turbine. Further investigation is in progress. H. R. C.

2077. *Increasing the Efficiency of Steam Engines.* **E. C. de Segundo.** (Elect. Rev. 46. pp. 1048–1049, June 22, 1900.)—Professor E. Josse, of the Royal Technical High School, Charlottenburg, has made experiments on a steam engine with which is combined an auxiliary engine utilising the heat contained in the exhaust steam; the invention of G. Behrend and Zimmermann. The heat contained in the waste steam is used to evaporate a liquid having a lower boiling-point than water, a solution of sulphurous acid having been chosen after many experiments; it is said to be cheap, and to lubricate the inner working surfaces of the machinery without corroding them. The steam engine has a stroke of 20 inches, and a speed of 41 r.p.m. From the low-pressure cylinder the exhaust steam passes into a surface condenser in which the cooling medium is sulphurous acid. This is immediately decomposed by the heat of the exhaust steam, sulphur dioxide gas is liberated and passes over into the cylinder of the auxiliary engine. This auxiliary engine has a cylinder 12 inches diameter, stroke 20 inches, r.p.m. 77. After passing through the cylinder the sulphur dioxide vapour enters a surface condenser where it is condensed to liquid by cold water flowing around the tubes as in an ordinary steam plant. The steam engine developed 34 I.H.P. with a steam consumption of 18·96 lbs. per I.H.P. hour. The auxiliary engine indicated 19 H.P.; reducing the steam consumption to 12·13 lbs. per I.H.P. hour. A. S.

2078. *Steam Jets* **W. Rosenhain.** (Inst. Civ. Engin., Proc. 140. pp. 199–219, June, 1900.)—The reaction of the jet is measured directly by equipoising, and the rate of flow of the steam is deduced from a separate experiment at the same pressure by condensing and weighing the discharge. Several different nozzles were used, including a sharp-edged orifice and tapering tubes of various proportions. As a result of the experiments it is stated that to give the greatest kinetic energy per lb. of steam the best nozzle is, for pressures below 80 lbs. per sq. in., a sharp-edged orifice, and for pressures above that, a very slightly expanding cone. Several diagrams of results are given. H. R. C.

GAS AND OIL ENGINES.

2079. *Crossley 350-H.P. Gas Engine.* (Engineer, 90. p. 68, July 20, 1900.)—The largest gas engine yet built by Crossley Brothers has two horizontal cylinders 26 inches diameter by 36 inches stroke, placed end to end on opposite sides of the crankshaft; the normal speed is 150 r.p.m. The engine is designed to work with Mond producer gas, and drives a dynamo direct by means of a flexible coupling. The output is 2,250 amperes at 110 volts, equal to 332 E.H.P. The engine has to run day and night for long periods without stopping.

The very heavy fly-wheel is built up in halves by a novel method of making the joints. It consists of dovetailed clips of good quality steel, machined, and carefully fitted, having taper of ⅛ inch to 1 foot, and driven on to corresponding machined joggles. The ends of the clips are also fitted to under-cut surfaces on the rim which prevent them from springing when strained. The internal sections are bolted together. There are thus definite stresses in the material which binds the sections together.

The speed is regulated by a centrifugal governor, varying the quantity of Mond gas mixing with the air in the charges of constant volume, there being no cut-out until the load on the engine falls below half the normal.

The ends of the cylinder water-jackets have detachable covers. The exhaust valves are fitted in detachable boxes instead of being cast on the cylinders. An equilibrating arrangement has been adopted which facilitates the opening of the large exhaust valves and relieves the working parts of undue strain. The exhaust valves and spindles are hollow, with water circulation through them to keep them cool and for efficient lubrication. W. R.

2080. *Valves of Internal Combustion Engines.* **J. D. Roots.** (Engineer, 90. pp. 49–51, July 20, 1900.)—The exhaust valve is opened positively, that is by mechanical means actuated by the crankshaft of the engine. Only in small engines, as used for the propulsion of vehicles, the charge admission valve is opened automatically by atmospheric pressure. The valves are closed by a spring which produces a blow on the seating. The strength of the spring should only be a very slight amount in excess of that necessary to close the valve. According to present practice the best angle for the seating of the mushroom valve is 45°.

Common forms of valve are shown, suitable for charge, air, and exhaust valves; and their defects discussed. The slot, to enable the valve to be ground in, may be cut across the top or in a projection. The width of the seating should be from one-eighth in small valves to one-seventh of the outside diameter in large ones. In a spirit engine the exhaust valve becomes more corroded than in gas and oil engines, where it lasts for nearly double the time before requiring regrinding. High-speed valves should be made of mild steel.

The valve-box and spindle-guide should be in one casting, so that when the guide is bored out accurately, and the seating turned true with the bore, the valve remains true after years of wear and repeated regrinding. If made separate or insufficiently water-jacketed, the exhaust valve-box and spindle-guide may so warp that the valve rests upon a small part of one side of the seat, causing leakage. In a large high-speed gas engine the inlet valve-box as well as the exhaust should be water-jacketed.

In an engine running at 750 r.p.m., the valve begins to open when the piston has traversed four-fifths of the working stroke, remains open during the whole exhaust stroke, and closes just *after* the dead point. In large engines of 200 r.p.m. the exhaust valve opens at from six-sevenths to seven-eighths of the working stroke. This valve and opening mechanism must be made to withstand the total pressure of 35 to 50 lbs. per square inch of valve area at the time of opening.

Formulæ are given for the proper area and lift of valves. The range of lift should be from $\frac{3}{32}$ to $\frac{3}{16}$ inch. The higher the speed and the smaller the valve the less will be the lift; and the converse holds true, the slower the speed and the larger the valve the greater the lift given within this limit.

W. R.

AUTOMOBILISM.

2081. *Acetylene as Motive Power for Vehicles.* **E. C. Oliver.** (Horseless Age, 6. pp. 12–14, June 20, 1900.)—In the manufacture of calcium carbide one H.P. hour produces 0·3 lb. of carbide of good quality, or about 7,000 H.P. hours per ton. At Niagara, taking 18 dollars per electrical H.P. per year, the price of calcium carbide is 75 to 80 dollars per ton. Good commercial carbide gives nearly 5 cubic feet of acetylene gas per pound, when decomposed by water, and in the reaction the heat evolved amounts to 900 B.Th.U.

In the various types of gas generators, either the water is fed drop by drop on the carbide, or the carbide is added in small lumps to a large quantity of water which takes up the heat generated and keeps the carbide cool. Acetylene gas polymerizes at 600° C., forming benzol, and by interaction naphthalene and other compounds with tarry products. Pure acetylene has an ether-like odour, and the strong, unpleasant smell of the commercial product is due to the impurities, phosphoretted hydrogen and sulphuretted hydrogen. Acetylene may be liquefied at its critical temperature, 97° F., by a pressure of 68 atmospheres, or at 68° F. by 42·8 atmospheres. In this state one volume of liquid acetylene will produce 340 volumes of free gas. The liquid is of specific gravity 0·4, water being 1; and one volume at 32° F. expands to 1·24 volumes at 96° F. It may be fired by a spark or incandescent wire and detonates with violence like an explosive. At 59° F. and atmospheric pressure, acetone (C_3H_6O) absorbs 25 times, and at 12 atmospheres 300 times, its volume of acetylene gas. This mixture is explosive at pressures above 28 up to 142 lbs. per square inch. Acetylene alone will not explode until the pressure is 1·05 atmosphere, but above this pressure it is violently explosive, consequently it should not be kept under a pressure of more than a few inches of water. At atmospheric pressure a mixture in the proportion 1 of acetylene gas to 1 of air, burns with sooty flame, and 9 to 12 of air to 1 of acetylene gas gives strongest explosion. Even 25 volumes of air to 1 of acetylene gives combustion without explosion. P. Ravel states that the temperature required to explode this gas is about 900°, and the temperature of explosion reaches 7,200° F.; whereas mixture of coal-gas and air ignites at 1,100° F.

With a 2-H.P. motor he obtained one H.P.-hour on 6·85 cubic feet of acetylene, using a mixture 15 of air to 1 of gas. The acetylene gave 2·1 times the power of coal-gas. He could not use more than 5 per cent. of gas in the mixture with high compression, as the explosions became violent and the pressure was extremely great, yet it fell off at once and expansion was not sustained.

The points to be noted regarding the behaviour of the gas are: (1) The low ignition temperature; (2) the great velocity of flame propagation; (3) the high temperature of combustion; (4) great energy of explosion; (5) the wide range of its explosive mixtures. To avoid premature ignition the engine cylinder must be kept at a low temperature, and then the cooling action of the walls would greatly lessen the effective pressure of expansion. The shock by explosion would necessitate greater area of bearings, and stiffer construction. At present acetylene is more expensive than gasoline, and the acetylene motor, with reciprocating piston, subject to great wear and tear, is in the experimental stage, where it is likely to spend a considerable time, though one may be built which will prove not only successful but popular. W. R.

2082. *Acetylene and Alcohol for Motors.* **P. M. Heldt.** (Horseless Age, 6. pp. 16–17, June 20, 1900.)—*Acetylene* gas has a calorific value of 12,200 calories per kg., and gasoline 11,360 calories per kg. One kilogramme of calcium carbide yields 300 litres of acetylene at atmospheric pressure, or nearly 5 cubic feet per lb. In a stationary engine the carbide for 1 H.P. hour weighs at least 500 grammes, and requires 273 grammes of water, making a total weight of 773 grammes; whereas in an engine of the same size, the gasoline required weighs only 267 to 334 grammes, and costs less than acetylene. It is very difficult to regulate the production of acetylene on automobiles to suit the change of road surface.

Alcohol.—The use of alcohol in internal combustion motors has been tried by French automobilists. The heat energy of a kilogramme of pure alcohol is 7,183 calories. Practical tests, of a gasoline motor with alcohol, give a reduction of motive power of about one-third. In a trial run between Paris and Chantilly, a distance of 42 km., with a light vehicle weighing 400 kilos. (880 lbs.) and carrying two passengers, the consumption of alcohol was 19 litres in 4 hours 8 minutes. With gasoline it would have taken 11 litres. The cost of alcohol fuel for this trip was found to be about three times as high as for gasoline. The run was made with ordinary pure alcohol, and not the denaturated alcohol, of which it is supposed the price can be reduced by relieving it of the taxes. Comparing the prices in the United States, the chances of calcium carbide and alcohol being applied to the propulsion of motor vehicles in place of gasoline are very small. W. R.

2083. *Acetylene and Gasoline for Motors.* **L. Berger.** (Horseless Age, 6. p. 20, June 20, 1900.)—This is a theoretical comparison of the results from acetylene and gasoline exploded in the cylinder of an automobile motor.

Acetylene, C_2H_2, has a specific volume at 0° C. and 760 mm. of mercury, of 860 litres, or 0·860 cubic metre per kg. Berthelot finds that 1 kg. of acetylene by decomposition gives 2,235 calories, and by complete combustion with 9·281 cubic metres of air yields 9,490 calories, or a total of 11,725 calories per kg. On explosion in a closed vessel, if the initial pressure be denoted by 1, that after explosion will be 17·2. The corresponding rise in temperature is 5,226° C., and the volume of gases on cooling to their initial temperature and pressure is $\frac{3}{3·5} = 0·85$ of their original volume before explosion.

Gasoline, of density 0·700, is chiefly hexane, C_6H_{14}; and the specific volume of its vapour, at 0° C. and 760 mm. of mercury, is 0·260 cubic metre per kg., and vapour density 2·975, air being 1. One kilogramme of gasoline vapour requires for complete combustion 10·667 cubic metres of air. This mixture, 13·4 volumes of liquid gasoline to 100,000 of air, or 2·4 per cent. of vapour at 0° C., gives 11,086 calories per kg. of gasoline. The rise of temperature is 4,191° C.; and the factor for increase of pressure is 20·2; and the resulting volume, when cooled, is $\frac{13}{10{\cdot}5}$, or 1·24 times the original. Here the proportion of gasoline vapour to air is 1 to 41 at 0° C., while for acetylene it is as 1 to 11.

In France, the experiments by G. Richard on a Benz motor with acetylene have shown that the explosion is rapid and violent, and the regulation of the mixture is difficult. The initial decomposition of the gas results in a deposit of carbon on the cylinder walls with loss of heating power. In spite of the troubles in gasoline carburetion by change of vapour pressure due to change of temperature at the carburetter, the conclusion is that better results are to be expected with gasoline than with acetylene in automobile motors. W. R.

REFERENCE.

2084. *Feed-water Heaters*, II. **J. F. Hobart.** (Amer. Electn. 12. pp. 354–356, July, 1900.)—A continuation of previous articles on this subject [*cf.* Abstract No. 1551 (1900)] the apparatus here described and illustrated being the Baragwanath, the Jacobs, the Jackson, the Wainwright, the Kensington, the Cochrane, and the Webster heaters. F. J. R.

GENERAL ELECTRICAL ENGINEERING.

2085. *Connecting up Electric Batteries.* **F. Vogel.** (Centralblatt f. Accumulatoren- u. Elemententenk. 1. pp. 2–3, Jan. 1, 1900.)—Reference having been made to some results obtained by F. Auerbach (Elektrotech. Zeitschr. 1887, p. 66), the author finds the least number k of cells required for sending a definite current i through a given external resistance w_a, to be as follows, viz. :—

$$k = \frac{4i^2 w w_a}{E^2}\,;\; n = \frac{2iw_a}{E}\,;\; m = \frac{2iw}{E}$$

where $w =$ the internal resistance and $E =$ the E.M.F. of each cell ; $n =$ the number of cells in series, and $m =$ the number of parallel groups of cells. The efficiency of this arrangement is 50 per cent. The case in which the amount of material used in generating current is to be as small as possible is next considered. The equations obtained show that for this purpose as many groups as possible should be put in parallel. When the costs of installation and working are both taken into consideration, the following results are obtained, viz. :—

$$k = \frac{iw_a . iw}{E^2}\left\{2 + \frac{\dfrac{Eit\Sigma(ag)}{iw} + 2\dfrac{Ap}{100}}{\sqrt{\left(\dfrac{Ap}{100}\right)^2 + \dfrac{Ap}{100} . \dfrac{Eit\Sigma(ag)}{iw}}}\right\}$$

and—

$$n = \frac{iw_a}{E}\left\{1 + \sqrt{\frac{\dfrac{Ap}{100}}{\dfrac{Ap}{100} + \dfrac{Et\Sigma(ag)}{w}}}\right\}$$

where $A =$ the prime cost of one element ; $p =$ the percentage amortisation per annum ; $t =$ the number of time-units of working per annum ; g_1, g_2 are the corresponding electro-chemical-equivalents of the substances consumed (*e.g.*, zinc) ; and a_1, a_2 are the costs of unit-quantity of the several substances.

C. K. F.

2086. *Aluminium-Magnesium Alloys.* **R. H. Thurston.** (Science, 11. pp. 783–785, May 18, 1900.)—The author points out that in 1893 an account had been published of investigations on the "newly-discovered" series of alloys. The average breaking strength of magnesium is 22,250 lbs. per square inch, average elastic limit 8,870 lbs. per square inch, average elongation 2·8 per cent. The density of the metal is only two-thirds that of aluminium, but it has one-half more tensile strength. The addition of magnesium to aluminium steadily reduces ductility, until at one-third magnesium and two-thirds aluminium, the alloy is as brittle as glass. The volatility of the lighter metal is an element of difficulty in its use in alloys, especially with those which have a high temperature of fusion. The extreme range of the tenacities of magnesium was between 20,000 and 30,000 lbs. per square inch, corresponding to a suspension of 30,000 to 40,000 feet ; this is the equivalent of steel of about 100,000 lbs. tenacity. Could the cast portions of the steam engine be made in this material, their weights would be reduced about one-half; it is therefore possible that magnesium with its high tenacity and great lightness may prove the coming material for work in which these qualities are important. A. S.

2087. *Voltage Regulator for Three-phase Circuits.* **G. Zweifel.** (Ind. Élect. 9. pp. 281–283, July, 1900.)—The use of an ordinary reactance or choking coil for purposes of regulation is attended with the following disadvantages: (1) The limits within which regulation is possible are very narrow if the current is variable. Thus, a coil which allows of a 10 per cent. regulation with the normal current is only capable of a 5 per cent. regulation at half-load, and has practically no effect at light load. (2) The coil introduces a phase difference (thus reducing the power factor) which may become considerable if regulation within wide limits is required. Both these disadvantages are done away with in the apparatus described by the author, which is intended for three-phase circuits, and consists practically of two induction motors whose rotors (which carry the primary or inducing winding) are mounted on the same shaft, and are not allowed to rotate, but may be displaced, by means of suitable gearing, through any desired angle. Fig. 1 shows the arrangement of connections, FF denoting the fixed windings of the regulator, which carry the main currents, and in each of which an E.M.F. of fixed magnitude $e/2$ is induced by the movable windings MM, which are supplied at a constant P.D. (E), being in connection with the generator terminals or 'bus bars. Fig. 2 is an E.M.F diagram. The phase of the induced E.M.F.'s, $e/2$, may be varied by altering the position of the movable inducing windings. From fig. 2 it is evident that the limits of regulation are given by $E \pm e$, and that the added or subtracted E.M.F. is always in phase with the generator P.D. Further, on account of the double arrangement of circuits, there is no resultant torque on the movable portion of the apparatus, the two equal and opposite torques acting on the two sets of windings merely producing a torsion of the shaft.

A. H.

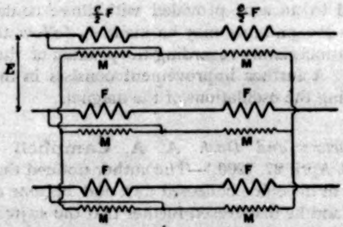


Fig. 1.

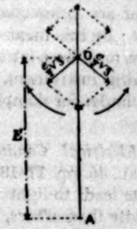
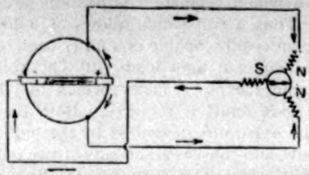


Fig. 2.

2088. *Electric Dial Ship-Telegraph.* **F. Querengässer.** (Elektrotechn. Zeitschr. 21. pp. 602–604, July 19, 1900. Paper read before the 8. Jahresversammlung des Verbandes Deutsch. Elektrotechn. at Kiel.)—The principle of the arrangement will be understood by reference to the accompanying sketch, which shows the connections used in the earlier form of this instrument. A closed circular resistance coil is supplied, by means of the signalling arm, with current at two diametrically opposite points. Three points in the coil, spaced 120° apart, are connected, by means of three wires, with the three coils of the receiving instrument. These three coils produce a rotating field as the signalling arm is turned, and the magnet which carries the pointer moving over the dial of the receiving instrument takes up a certain position for each position of the signalling arm. The following improvements have recently been introduced into this instrument. In the earlier form the currents did not follow the sine law, with the result that variations in the E.M.F. caused changes in the position of the magnet in the receiving instrument. In the more modern form, the



resistance coil is subdivided into sections of unequal resistance, and current is supplied to it at two fixed points; while the three line wires from the receiving instrument are connected to an arm provided with three contacts spaced 120° apart; by this means the currents may be made to follow the sine law accurately, and there is no uncertainty regarding the position of the pointer in the receiving instrument. A further improvement consists in the use of a copper cylinder for damping the oscillations of the magnet. A. H.

2089. *Electrical Conductors and Dust.* **A. A. Campbell Swinton.** (Electrician, 45. pp. 17–18, April 27, 1900.)—The author noticed that some of the flexible leads to lights in his office collected dust and became dirty much more rapidly than others, and he discovered further that the switch in circuit with those leads which collected the dust rapidly was in the negative side; whereas the switch of the clean cord circuits was in the positive side. The phenomenon is due to the fact that the negative main always tends to earth itself. For example, on the Westminster Company's system a test showed that from the negative there are 30 volts to earth, while from the positive there are 170 volts to earth. Consequently, in the case of lights having a switch in the negative side, the flexible cord is at a potential of 170 volts whenever the lights are not on, and dust is attracted much more than when the switch is in the positive. E. D. P.

2090. *Electrical Conductors and Dust.* **F. G. Baily.** (Electrician, 45. pp. 604–605, Aug. 10, 1900.)—Referring to the paper dealt with in the preceding Abstract, the author states that of two conductors, one positive and the other equally negative, the positive attracts dust slightly more than the negative. In the case of switches, an earthed cover is recommended as a preventive against deposit of dust on the adjacent wall. W. H. E.

2091. *Krizik's Electric Block System.* **J. Guillaume.** (Écl. Électr. 24. pp. 5–16, July 7, 1900.)—This is a new system shown at the Paris Exhibition in the Austrian section. A battery of accumulators is required at each station. For charging them a trolley is employed carrying a motor, worked by benzine, and a dynamo, and this can be, of course, run from station to station as required. When in use for charging, one pair of the trolley wheels is raised off the line, and by being coupled to the motor shaft acts as a fly-wheel. The electric semaphore can have its lever attached to any existing railway signal. It is operated by an electric motor within a cast-iron case. Weights and restoring springs are dispensed with. The motor is reversible in movement by change in the direction of the current, and when moved one way raises, and the other lowers, the signal arm. The movement operates also a commutator which enables the current to be reversed when an appropriate key is used at the distant station, or at the signal-box connected with the semaphore. But the reversal of the motor so as to alter the position of the arm cannot be effected without the co-operation of the train, when the arm is to "danger." When the train has passed the semaphore, one of the rails is slightly deflected by the weight of the engine, or waggon, and caused to complete the necessary circuit to raise the semaphore behind, or an insulated rail can be used, and the required contact then takes place through the wheels and axle to earth on the other side of the line. So that with this system there is no alteration needed nor attachments necessitated in existing rolling stock. The block instrument at the station or signal-box in rear is operated by the contacts in the semaphore case (which are changed by the motor), so that, when the arm goes up, the visual signal of the instrument at the last protected point becomes red, and when the arm falls, becomes white, thus blocking and unblocking the section. The current is only flowing while these signals are working, so that there is no waste. For the exact mode of operation the diagrams with the description should be referred to. The electro-motor is four-pole with inducing bobbins, carefully protected from damp. The change of direction of rotation is obtained in one of the following ways : The inductor can have two windings opposed the one to the other, the current being sent through one to signal "danger," and through the other for "line clear" ; or, using one winding on the inductor, send, for one class of signal, the current through this, and the induced coils as a motor in series, and for the other class adopt the parallel arrangement, regulating the movement if necessary by a resistance between this circuit and earth. E. O. W.

2092. *Swing Bridges at Northwich.* **J. A. Saner.** (Inst. Civ. Engin., Proc. 140. pp. 72–84 ; Discussion, pp. 85–108, June, 1900.)—The Northwich Bridge, a plate girder structure of 90 feet span, had caused, owing to the subsidence of the district, great inconvenience to the river traffic through the constantly decreasing headway. The average loss of headway over a period of sixteen years had been 4¼ inches per annum. Parliamentary powers were granted for the erection of two swing bridges, some distance apart, so that one bridge could always be available for road traffic. The form of bridge adopted by the author consists essentially of (1) a pair of bowstring lattice girders carrying the roadway ; (2) a circular pontoon placed under the centre of gravity of the superstructure, rigidly connected thereto so as to be always submerged in the river, and capable of being turned with the superstructure ; (3) a group of cast-iron screw piles surrounding, but clear of, the pontoon, and carrying a gridiron girder, which in turn carries the bottom roller path. The upward buoyancy of the pontoon is less than the aggregate weight of the superstructure, by a quantity which can be varied at will within certain limits. For example, if the total weight of the superstructure and pontoon is 303 tons, and the normal buoyancy of the pontoon 255 tons, the weight resting on the rollers and piles is 48 tons. In the event of adjustment being required, therefore, only 48 tons have to be dealt with, and even this can be reduced to 28 tons by emptying the upper part of the pontoon.

The constructional details of the bridge are described at length. The motive power used for operating the bridge is electricity, taking from the Northwich Electric Supply Company at 440 volts. The gates for the town bridge are moved by two 4-B.H.P. motors, controlled by a switch placed near the cabin door. For the turning gear, the power is transmitted from the machinery house to the bridge by means of two 1¼-inch wire ropes wound opposite ways round a vertical barrel, and fixed to the circular girder of the bridge. The navigation bridge had up to the time of writing been opened and closed 155 times; as a rule, the gates can be closed, wedges withdrawn, and bridge turned in 1½ minutes. The electric current used for the complete operations of opening and closing is ¼ unit, costing 1d. The electric machinery, &c., cost £1,100 for each bridge. A. S.

REFERENCES.

2093. *Lightning Conductors.* **A. della Riccia.** (Elettricità, Milan, 19. pp. 146–151, March 10, 1900. From the *Rivista di Artiglieria e Genio,* 1900.)—The author gives instructions for erecting lightning-conductors on buildings of various descriptions, with special reference to powder magazines. G. H. B.

2094. *Electric Cranes.* (Elect. Rev. 45. pp. 803–807, Nov. 17, 845–847, Nov. 24, 1899; 46. pp. 57–60, Jan. 12, 427–428, March 16; 47. pp. 167–168, Aug. 3, and 212–214, Aug. 10, 1900.)—Various forms and their application.

2095. *Standard Specifications for Iron and Steel.* (Mech. Eng. 5. pp. 795–797, June 9; 838–840, June 16; and 891–893, June 23, 1900.)—The tentative specifications prepared by the American Section of the International Association are here published; they will be fully discussed later on by the American engineering societies before being adopted. The specifications and methods of testing prescribed refer to—(1) Structural steel for bridges and ships, (2) steel for rails, (3) steel castings, (4) steel forgings, (5) boiler plate and rivet steel, (6) steel axles, (7) steel tyres, and (8) wrought iron.

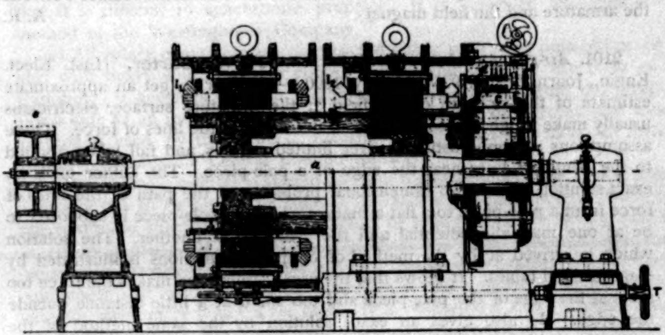
2096. *Direct-connected Water-wheels and Generators.* **F. C. Perkins.** (West. Electn. 26. pp. 234–235, April 14, 1900.)

2097. *E. P. Storage Battery.* **H. S. Martin.** (Elect. World and Engineer, 35. pp. 635–636, April 28, 1900.)—An illustrated article giving general particulars of the design and capabilities of this cell. E. J. W.

2098. *Electrical Progress.* **A. W. Heaviside.** (Inst. Elect. Engin., Journ. 29. pp. 900–924, July, 1900.)—An inaugural address, delivered before the Newcastle section and mainly of historical and local interest.

2099. *Lightning Conductors.* **K. Strecker.** (Elektrotechn. Zeitschr. 21. pp. 583–584; Discussion, pp. 584–589, July 12, 1900.)—In 1894 a committee was appointed by the Elektrotechnische Verein to establish a set of rules for the erection of lightning conductors. The paper is a report of a meeting of the Elektrotechnische Verein at which certain proposed rules were read and discussed. The text of the rules is not given, and many references to them in the discussion are therefore unintelligible. Weinhold gave interesting statistics as to the number of protected and unprotected buildings struck by lightning in different parts of Germany, and as to the amount of damage done. The rules were reserved for further consideration. G. H. B.

GENERATORS, MOTORS, AND TRANSFORMERS.



2100. *Grammont Alternator with Hutin and Leblanc Compensating Exciter.* **J. L. Routin.** (Ind. Élect. 9. pp. 249–255, June 25, 1900. See also Electrician, 45. pp. 844–848, Sept. 28, 1900.)—An illustrated description is given of the 600 kw. three-phase alternator exhibited by A. Grammont at the Paris Exhibition. The rotating part of the three-phaser is an inductor wheel with 64 radial poles on its circumference, which makes 93·75 revolutions per minute. The frequency of the alternating current is therefore 50. The stationary part is star wound, and the potential difference between the terminals is 2,400 volts. On a non-inductive load the electrical efficiency is 95 per cent., and when the power factor is 0·7 the efficiency is 93 per cent. A special feature of this alternator is the compensating exciter used. The exciter is geared to the shaft of the alternator by a toothed wheel and pinion, but when the alternator is working the effect of the gearing is to prevent the armature of the exciter from going too fast, work being done on the shaft by the exciter. The armature of the exciter is not unlike the armature of a multipolar direct current dynamo, and has two cores, D, E. It is subjected to the action of two independent rotating magnetic fields s_1, s_2. The stator s_1 is placed as a shunt across the alternator terminals, and the stator s_2 is in series with the armature windings. Two stators are necessary, as it is essential that the resultant rotating magnetic field in which the armature of the exciter revolves should always be proportioned to the resultant magnetic field of the three-phaser. There are three pairs of poles on the stators, and six pairs of brushes on the commutator of the armature. These brushes collect direct current for the inductor circuit of the three-phaser; and, owing to the design of the winding and the angle at which the stators are fixed relatively to one another, no adjustment of the brushes is necessary whatever the load or the power-factor may be. The two stators also regulate so as to do away with the necessity of an adjustable resistance, and so the machine is self-regulating at all loads and power-factors. The author gives a full explanation of the theory, and he also gives diagrams of the winding of the exciter. He gives the following equation to determine the speed of the armature of the exciter in order that direct current may be taken from its commutator with fixed brushes :—

$$N = \frac{f}{n + k}$$

where n = the number of pairs of poles of the stators,
k = the number of pairs of brushes,
f = the frequency of the alternating current,
N = the number of turns the armature makes per second.

In the above equation the armature and the rotating magnetic field are supposed to revolve in the same direction. If they revolved in opposite directions we should have to write $-k$ for k. In the Hutin and Leblanc exciter they rotate in the same direction, and in the case under consideration $n = 3$, $k = 6$, and $f = 50$, hence N is $\frac{50}{9}$, and the armature must rotate 333 times per minute. The author states that the principle of this compensating exciter, although quite accurate enough for practical work, is not absolutely correct. In order to be exact, the self-inductance of the armature circuit would need to be always in a constant ratio to the mutual inductance between the armature and the field magnets. A. R.

2101. *Air-gap and Interpolar Induction.* **F. W. Carter.** (Inst. Elect. Engin., Journ. 29. pp. 925–933, July, 1900.)—In order to get an approximate estimate of the strength of the field at the armature surface, electricians usually make rough assumptions about the shape of the lines of force. These assumptions are only justifiable over limited regions, and fail when applied to the fringe of lines near the edge of a pole-piece. The author gives an exact solution of the two dimensional problems of the path of the lines of force from a pole-piece to a flat armature when the pole-piece is supposed to be at one magnetic potential and the armature at another. The solution which is arrived at by the method of conjugate functions is illustrated by diagrams and tables. It shows that the usual assumption makes the force too great at the edge of the pole-piece and too small at a little distance outside the edge. He also gives an exact solution by the same method of the magnetic problem presented by two unlike rectangular poles and a straight armature. If we suppose the poles to be increased in breadth by a length x until the total breadth multiplied by the maximum value of the flux density will give the total flux, then—

$$\lambda = \frac{x}{g} = 0{\cdot}72 \log\left(\frac{1}{4} + \frac{c^2}{4g^2}\right) + \frac{1}{90}\left(\frac{c}{g}\tan^{-1}\frac{g}{c}\right),$$

where $2c$ is the distance between the poles and g is the length of the air-gap. In the case when c equals $4g$ then λ equals 1·07, a value very much smaller than that obtained (1·76) by Hawkins and Wightman on p. 449 of the same volume of the Journ. of the Inst. of Elect. Engin. A. R.

2102. *Converters for Tramway Sub-stations.* **A. C. Eborall.** (Tram. Rly. World, 9. pp. 326–328, July, 1900.)—An important article dealing with the advantages and disadvantages of rotary converters and motor generators for tramway substations. Converters must be reliable and efficient, and also able to work perfectly in parallel, not only one machine with another, but one substation with another. So far in Great Britain all tramway installations have followed the lead of the States simply because up to the present American contractors have been given the work. The author thinks that in future it would be wiser to take a broader view of the questions involved.

The most striking feature of a rotary converter substation is its complication. Transformers must be inserted between the high pressure lines reducing the voltage to 330, and there is also the switch gear required on the two sides of each rotary; for although they can be started up from the continuous current side, yet it is absolutely necessary for each rotary to be capable of starting up from the three-phase side in case direct current supply is not available. Usually one of the following methods has to be arranged :—

(*a*) A starting set is installed in each sub-station, consisting of a 330-volt three-phase motor coupled to a shunt dynamo, the output of the set being about 7½ per cent. of that of the largest rotary. For starting, all that has to be done is to use the direct current produced by this set to start any rotary from its direct current side. The adjustment of speed necessary for synchronising is easily made by means of the starting resistance and the shunt regulator of the rotary.

(*b*) An induction motor is direct coupled to each rotary for starting up. This will have an output equal to 7 to 10 per cent. of the full load output of the rotary in question, and the chief objection to the method lies in the fact that it is difficult to synchronise properly. It is, however, the standard method of the Westinghouse Company.

(*c*) All rotary converters are constructed either with solid pole-pieces, or else with heavy short-circuited copper straps wound round the polar extremities. It becomes possible, therefore, to start a rotary from the three-phase side as an induction motor by merely switching on current, and this method is used by the General Electric Co. (U.S.A.) for most of their plants, including the Central London Railway.

If the rotary converter is started up from the three-phase side then a pole indicator has to be placed on each D. C. panel to indicate the pole at which the rotary has synchronised. If it should be found to be the wrong one (it is purely a matter of chance) the operation has to be repeated until the polarity of the direct current side is right. Hunting is another trouble very commonly met with in rotaries, especially if the angular velocity of the engines varies more than 0·2 per cent. It is increased if there is much drop on the transformers and cables, and a slight displacement of the brushes on the direct current side may start a group of rotaries hunting, accompanied by violent sparking.

To assist parallel running, "Amortisseurs" are sometimes used; they consist of copper bands embedded in the pole-pieces and short circuited individually. If, however, the pole-pieces of the rotaries are solid and of sufficiently massive design, they will to a large extent take the place of these damping coils.

The design of the rotary converter is not flexible, because in order to keep the speed within reasonable limits either the frequency has to be low or the number of poles very large. A frequency of 25 to 30 cycles is usually chosen; and it is only on account of the small armature reaction (due to the neutralising action of the two sides) that it is possible to operate such machines satisfactorily in spite of the excessive number of field poles.

Over-compounding is generally arranged for by compounding the rotary in the usual manner, and also having a set of choking coils between the slip rings and the low-pressure side of transformers. At no load the field of the rotary is slightly under excited, and due to this and the choking coils the three-phase currents in the armature lag behind the impressed voltage. As the load comes on, the field is strengthened, on account of the current in the series winding, thus diminishing the armature currents, raising the volts between the slip-rings, and consequently the volts on direct-current side.

In substations which are equipped with asynchronous motor generators there will be an idle current of 8 to 10 per cent. for which provision must be made in the line. On the other hand, as there is no synchronising the starting up is reduced to its simplest form, perfect parallel running is possible, and the amount of supervision is reduced to a minimum. E. K. S.

2103. *Maximum Efficiency of Transformers.* **F. G. Baum.** (Elect. World and Engineer, 35. p. 979, June 30, 1900.)—The efficiency of transformer at any load is given by the equation—

$$\epsilon = \frac{E_2 I_2 - I_2^2 R_2}{E_2 I_2 + I_2^2 \frac{R_1}{n^2} + W_0} \qquad (1)$$

where E_2 is the total induced secondary pressure, I_2 the secondary current, R_1 and R_2 the primary and secondary resistances, n the ratio of transformation, and W_0 the total core losses. The author does not prove that $nI_1 = I_2$. Making the assumption that W_0 and E_2 are constants, the equation to determine the value of I_2 which makes ϵ a maximum can be written in the form—

$$\frac{I_2 R_2}{E_2} = \frac{W_0 - I_2^2\left(R_2 + \frac{R_1}{n^2}\right)}{2W_0} \qquad (2)$$

In practice the left-hand side of this equation is never greater than 0·03, and hence the author states that no great error is made by using the ordinary rule that the efficiency is a maximum when the core losses equal the copper losses. He also makes some deductions from the second equation. A. R.

REFERENCE.

2104. *Design for a Simple Transformer in Four Sizes.* **C. P. Poole.** (Amer. Electn. 12. pp. 348–350, July, 1900.)—Full and clear instructions are given for the construction of small transformers which transform from 1,000 to 100 volts, and whose outputs are 0·2, 0·5, 0·75, and 1 kw. respectively. A. R.

ELECTRICAL DISTRIBUTION, TRACTION, AND LIGHTING.

ELECTRICAL DISTRIBUTION.

2105. *Electrical Distribution.* **L. Andrews.** (Elect. Engin. 26. pp. 45–47 ; Discussion, p. 50, July 13, 1900. Paper read before the Municipal Electrical Association, June 22.)—Taking the case of Hastings, the author calculates the cost of distribution by direct and alternating current respectively, showing the former to require a capital outlay of £40,990 against £25,070 for the latter, while the total annual cost would be £5,424 for direct, and £3,836 for alternating current. The system of duplication of feeders employed at Hastings is then described, and the use of discriminating cut-outs explained. During the hours of light load the whole of the distributing network is supplied through a transformer in the generating station, all feeders being disconnected. Pilot wires from the various substations to the generating station serve to indicate the pressure at the former, to give warning of faults in the feeders or transformers, to show when the latter are disconnected on the secondary side, and to close the switches in the substations when desired. Explanatory diagrams accompany the paper.

Discussion. **J. F. C. Snell** took exception to the author's figures of cost, and stated that there was little difference between the cost of the two systems compared. **C. H. Wordingham** agreed with this view, and said that in certain cases high pressure direct current was more advantageous than either.

A. H. A.

2106. *Reduction of Losses in Alternating Current Supply.* **H. Boot.** (Elect. Engin. 26. pp. 13–16 ; Discussion, p. 16, July 6, 1900. Paper read before the Municipal Electrical Association.)—The author gives tables of the initial core losses of a large number of transformers compared with the present values. At Tunbridge Wells the all-day efficiency of the transformers averages 94 per cent., the energy wasted during hours of light load costing over £200 per annum. This may be almost entirely saved by cutting out all transformers but one during light load. Fuses should be concentrated in the generating station, and the outer conductors of concentric cables earthed without fuses. To save the loss in the shunt coils of meters the author has devised an automatic relay, which interrupts the shunt circuit when no current is flowing through the meter. An appendix gives a quantity of information derived from seventeen undertakings.

Discussion. **H. F. Proctor** and **W. B. Esson** questioned whether it was worth while to introduce switch gear to save magnetising losses. A. H. A.

2107. *Effect of Transmission Line on Behaviour of Synchronous Motors.* **F. Eichberg.** (Zeitschr. Elektrotechn., Wien, 18. pp. 301–304, June 17, and 321–324, July 1, 1900. Paper read before the Elektrotechnischer Verein at Vienna, March 21.)—Taking the case of a generator, motor, and transmission line, the author deduces an expression for the mechanical power delivered to the motor in terms of the generator and motor E.M.F.'s and the phase angle ϕ between them. From the expression so obtained he arrives at an elegant graphical method of exhibiting the power as a function of ϕ, assuming constancy of the E.M.F.'s. The diagram is used for investigating the effect of changes in the resistance and reactance of the line on the overload capacity of the motor. A similar diagram is next constructed for the power developed by the generator, and the total efficiency of transmission is thereby determined. The second part of the paper deals with the effect of variable armature reaction, and with the hunting of synchronous motors and converters, as influenced by the transmission line. A. H.

2108. *Electric Mains at Cheltenham.* **H. Kilgour.** (Northern Soc. Elect. Engin., Proc. 5. pp. 99–112 ; Discussion, pp. 112–114, 1899.)—The generating station is 2,000 yards away from the principal substation, near the centre of the town, which is connected by radiating feeders to other substations, whence minor feeders run to more remote substations, where the transformation takes place from 2,000 volts to 200 or 100 for the distributors. All cables, except for services, are Callender's concentric, insulated with bitumenised fibre, and these have proved very satisfactory. They are mostly armoured, and are laid either direct in the ground or in wooden troughs filled with bitumen, according to the nature of the soil. As a further protection, a layer of bricks is in most cases placed above them. In a few principal streets unarmoured cables have been used, which are drawn into conduits composed of cement concrete with bitumenised paper ducts. The feeders are 37/16, 19/16 ; and 19/18 for arc lighting. The distributors are 37/12, 37/15, and 19/14. Some faults occurred at first in the 19/20 cables for arc lighting, owing to the fact that the number of wires in the outer conductor was not sufficient to completely surround the inner insulation. In such a conductor it was found that if any single wire parted, *e.g.*, at a factory joint, sparking occurred at the contact and eventually caused a fault. Also there was a special liability to mechanical injury in the case of these conductors.

Breakdowns at first occurred in some of the 650-watt transformers placed in the bases of the arc lamp posts. The cause appears to have been damp, and the transformers are now dried by sending current through them at low pressure for about a week, pots of calcium chloride being inserted through the fuse doors and all openings sealed up. The calcium chloride is changed from time to time. Short lead-covered cables are connected to the terminals of each transformer before it is subjected to the above treatment, and thus there is no occasion to open the case in the open air when fixing. In substations the transformers are mostly run with their top covers loose.

In localising faults in the mains, Murray's loop test is almost invariably used. The two portions into which the inner is divided at the fault, together with the cable used for connecting, form one pair of arms of the bridge, the other pair consisting of box resistances. Trouble due to faults and fault-finding is minimised by extensive sectionising of both high and low pressure mains.

The construction of the substations is described in some detail. W. H. E.

2109. *Power Supply by Single-phase Motors.* **T. P. Wilmshurst.** (Elect. Engin. 25. pp. 909–911 ; Discussion, pp. 913–914, June 29, 1900. Paper read before the Municipal Electrical Association, June 21.)—The author reviews the various objections to single-phase motors, pointing out that some are fallacious and others can be removed by proper arrangements. Efficiency tables and curves are given.

Discussion. **S. Z. de Ferranti** advocated the use of single-phase motors, and referred to the value of condensers in improving the power factor. **S. E. Fedden** cited instances where these motors had failed to give satisfaction.

C. Langdon-Davies and **R. C. Quin** pointed out that single-phase motors could not be efficiently operated by alternators giving irregular E.M.F. waves. **W. B. Esson** stated that two-phase machinery cost but little more than single-phase in construction. A. H. A.

2110. *Maintenance of Motors and Starting Switch Gear.* **C. A. L. Prüsmann.** (Elect. Engin. 25. pp. 911–913; Discussion, pp. 913–914, June 29, 1900. Paper read before the Municipal Electrical Association, June 21.)—Motors let out on hire seldom give trouble, but starting switches are as yet unsatisfactory. Liquid resistances with glycerine in the dashpots were tried at Bradford, but were too much affected by changes of temperature; oil dashpots also gave trouble, but air dashpots proved successful. Metallic resistance switches failed through sparking at the contacts. Compound motors were better than shunt-wound machines for cranes, taking a smaller starting current. Shunt motors were satisfactory on steady loads with simple slow-motion starters; no benefit was derived from automatic release devices. For loads subject to severe fluctuations, however, the overload release was indispensable. Motors below 3 B.H.P. cost more to maintain than the larger sizes; spur and belt gearing were practically equal in this respect. Open motors were much more subject to damage than the enclosed type. Injury to commutators was chiefly due to inefficient starters and bad foundations. The cost of maintenance is on the whole insignificant compared with the advantages of a motor load. A. H. A.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

2111. *Electricity in Steel Works.* (Elect. World and Engineer, 36. pp. 49–52, July 14, 1900.)—Electric power transmission is used in the Ohio works of the National Steel Company for very severe duties. Two immense travelling cranes, spanning the ore stock yard, are driven each by two 130 H.P. motors coupled together; these are geared by friction clutches to the various motions. The motors are provided with a weak shunt winding in addition to the main series coils to prevent excessive racing at light loads. Each traveller is capable of handling 1,750 tons of ore per day of ten hours. The waggons conveying the ore from the yard to the bins near the furnaces are all electrically driven, collecting current from two heavy copper trolley-wires running alongside the tracks. From the bins other electric waggons take the ore to the skips, which are hauled to the top of the furnaces by electrical winches. The skips are capable of lifting 16,000 lbs. of ore each, and are hauled to a height of 196 feet in thirty seconds; they are driven by motors of 275 H.P., provided with specially designed automatic controllers which govern the acceleration of the skips and stop them at exactly the right place. Numerous cranes, tables, drill presses, &c., are driven by motors, as well as a 125 H.P. cold saw and a 65 H.P. pig-casting machine. The generating plant consists of two 550 kw. dynamos, working at 250 volts pressure, and driven by compound engines of 1,400 H.P. each. Steam is supplied by a battery of boilers fired with blast-furnace gas. For lighting purposes inverted rotary converters are employed, giving two-phase 50-period alternating currents, which are transformed up to 2,000 volts for distribution. The pressure is controlled by regulators on the switchboards, as the ratio of conversion from direct current is invariable. A. H. A.

2112. *Polyphase Distributing System of the Metropolitan Street Railway Company of New York City.* **J. E. Woodbridge.** (Elect. World and

Engineer, 85. pp. 782–784, May 26, and 859–861, June 9, 1900.)—The first of these two articles is the seventh of a series [see Abstract No. 1872 (1900)], and deals with the substation high-tension circuits—of which a complete diagram is given—and also the six-phase connections to the rotary converters. Six phases are adopted in order to reduce the copper losses in the rotary armatures because, having no field distortion, the capacity of rotary converters is determined solely by their heating limit and commutating ability. Any means of reducing the heating therefore correspondingly increases the number of kilowatts which a given machine will convert, provided there is sufficient field strength to reverse the currents in the armature coils as the commutator segments pass under the brushes. Steinmetz has shown that a machine which will deliver 100 kw. without overheating when driven mechanically as a generator, will deliver 131 kw. with the same temperature rise when run as a three-phase rotary converter, and 194 kw. when run as a six-phase rotary, other conditions remaining the same. This is allowing for the internal losses of the converter and assuming that the impressed E.M.F. is in phase with the counter E.M.F. of the machine. If wattless currents are not carefully balanced or are used for purposes of regulation the output falls off somewhat. Assuming, for example, that a wattless component amounting to 30 per cent. of the total alternating current input of the machine is drawn in, the same 100 kw. generator will deliver 122 kw. as a three-phase and 167 kw. as a six-phase rotary. In addition to the reduction of the heating the six-phase arrangement distributes the heating much more uniformly round the armature.

The six phases are obtained from the three-phase step-down transformers, which are of the usual single-phase type and three in number, but have each two electrically independent secondaries. These six secondaries are connected up in two separate deltas, so that the rotary will still continue to work even if one transformer becomes crippled. The six collector rings are tapped to six points per pair of poles in the armature winding.

In the eighth article, particulars are given of the rotary converters and their switch gear, &c. The rotaries are 14-pole machines of 990 kw. output, but are able to give 100 per cent. overload for short intervals. The armature has 24 slots per pole, 4 bars per slot, and 48 coils and commutator segments per pole. The fields are compound wound, but up to the present the series coils have been cut out of service, as it has been found that the regulation is so very good, partly owing to the large generating capacity of the system, that the series fields and reactances are not needed. The batteries absorb momentary fluctuations of load, and there is no difficulty in working with them whilst the rotaries continue to be worked as shunt machines.

To reduce any tendency to hunt, copper tongues are inserted under the pole-tips, the eddy currents in which and in the solid steel of the poles, check any tendency of the pole flux to sweep from tip to tip. Oscillators, or end-play devices, are fitted to prevent the brushes from wearing tracks in the commutator and collector rings. Each rotary weighs 45 tons, of which the armature is 16 tons.

The following are the efficiencies: Double full load, 96·8 per cent.; full load, 96·0 per cent.; half load, 93·6 per cent. The step-down transformers give an efficiency of 98 per cent. under full load, and allowing 1½ per cent. loss in the high-tension feeders from the generating station to the substations, and a further loss of ½ per cent. in the substation for the blowers, reactive coils, motor generators, air-pumps, &c., it will be seen that the arrangement gives an all-day efficiency of over 90 per cent. between the switchboard of the generating station and the direct-current switchboards of the substation.

Particulars are given of the special switching gear on the direct-current switchboards. E. K. S.

2113. *Electric Traction on the London Metropolitan-District Railway.* (Electrician, 45. pp. 163–166, May 25, 1900. Also Electrical Engineer, May 25, 1900.)—In February, 1899, the Associated Metropolitan and District Railway Companies voted £20,000 for the electrical equipment of 5,000 feet of line between Earl's Court and High Street Kensington stations. The engineers, J. Wolfe Barry and W. H. Preece, were required to carry out the work on the permanent way without any interference with the running of the ordinary trains and without any electric current passing through the permanent way or subsoil, lest such should interfere with the signalling arrangements. In accordance with these requirements it became necessary to adopt an insulated return, and to do the whole of the construction work in the few midnight hours when the trains were not running. The electrical work was placed in the hands of Siemens Bros. & Co. The electrical conductors, of inverted channel steel, weigh 75 lbs. per yard, and are carried on double petticoat insulators, the jar being taken by a piece of leather. At points and crossings the continuity of the electrical rails had to be broken, but the gap is in no case so wide that contact is not made in front before it is broken in the rear of the train, which is 245 feet long. The bonding is by copper strip hydraulically riveted. There are two positive and two negative feeders, lead-covered and armoured. The power house is of a temporary character and contains two Belliss Siemens sets and two Babcock-Wilcox boilers. The engines are 300 I.H.P. at 380 r.p.m., and the dynamos give 385 amperes at 550 volts. The boilers are each capable of evaporating 9,000 lbs. per hour for short periods.

There is only one train, by Brown, Marshall & Co., and it requires current for about 8 mins. in 20 mins. It has a motor car at each end, but only one is used at a time. In the event of this type of train being adopted on the Inner Circle it would of course only want one motor car, because the trains always move in the same direction. The train carries 312 passengers. The weight is: four coaches, 72 tons; two motor-cars, 90 tons; passengers, 20 tons. Each motor carriage has four four-pole 26 × 25 Siemens motors, series wound, with armatures built on the axles. Each motor develops a normal drawbar pull of 4,000 lbs., the wheels being 47 inches diameter, and the maximum power about 200 H.P.

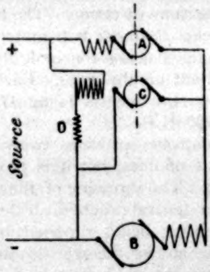
The series parallel controller provides twelve arrangements of motors. There are no short-circuit nôtches, but it is possible to reverse the motors whilst the train is running. The throwing of the motors against the train is not intended to be used in general practice, all the braking being done by a "Standard" air brake, the air being supplied by an electric three-throw pump, which also supplies air for the whistles and sanding gear.

Current is collected from the conductors by fourteen (seven on each side) cast-iron shoes suspended from the bogeys by insulated bolts. The springs are adjusted so that the bearing pressure is about 10 lbs. When fully loaded the train has started on a 1 in 43 gradient—a feat which an ordinary steam locomotive was unable to perform when hauling a similar load. Owing to the simplicity of the driving arrangements it has been found unnecessary to employ specially trained drivers. Maximum speeds of thirty-eight to thirty-nine miles an hour have been reached. E. K. S.

ELECTRIC TRACTION AND AUTOMOBILISM.

2114. *Electric Canal Haulage.* (Tram. Rly. World, 9. pp. 294–297, July, 1900.)—A system devised by L. Gérard has been installed on the important canal between Brussels and Charleroi, 50 miles in length. The present power station is at Oisquercq, 16½ miles from Brussels, and contains boilers and engines of 450 H.P. in all, driving three-phase alternators by cotton belts. Current is supplied at 6,000 volts pressure to the feeders, which are carried overhead at a height of 36 feet on three-bell insulators. A secondary three-phase line, working at 600 volts, is carried on the same poles at a height of 18 feet, and a 36 kw. transformer is placed in a substation every three miles. Along the towpath runs a four-wheeled tractor, fitted with a three-phase motor of 5 H.P. nominally, but capable of working up to 20 H.P. if necessary. The tractor weighs nearly 2 tons, and measures 7 ft. 9 in. long by 8 ft. 5 in. wide. It is provided with a clutch arrangement for coupling either to the driving axle or to a conical winch for use when a powerful effort is required. The current is collected by a triple trolley, weighing about 1¾ lbs. Each tractor runs over a certain section, drawing five boats, each laden with 10 tons, at a speed of 2½ miles per hour. At meeting-places, either the tow-ropes or the trolleys are exchanged. Besides providing for haulage, the system is used for lighting villages at night, and for supplying power to factories; 250 H.P. has been applied for, and 1,800 lamps are in use. The article includes illustrations of the apparatus used. A. H. A.

2115. *Solignac Compensator for Regulating Traction Motors.* **J. Reyval.** (Écl. Électr. 24. pp. 154–158, July 28, 1900.)—Large losses are incurred by the frequent starting of tramcars, and by running at low speeds. The Solignac compensator is used by the Société des Voitures Électriques to reduce this waste of energy. The compensator consists of a series-wound motor, A, coupled in series with the main motor, B, and driving a small dynamo, C, whose armature is connected in shunt with the terminals of the latter. The field of the dynamo is excited from the source of energy, and is regulated by a rheostat, D. At the moment of starting, the motor A rapidly runs up to full speed; the field of the dynamo C is excited, and the armature supplies current to the main motor B, the result being that the power supplied by the source is only half what it would be if a regulating resistance were used in the usual way. As the speed of the car and of the motor B increases, that of A and C diminishes, until the compensator becomes unnecessary and can be cut out of circuit. If it is desired to run at a low speed, however, the field of the dynamo is weakened and the compensator left in operation.



Curves are given showing the economy of power effected. In the case of a vehicle driven by a 6-H.P. motor, and carrying a battery weighing 1,100 lbs., with a rheostat weighing 66 lbs., by replacing the latter with a compensator of 132 lbs. weight, the battery may be lightened to the extent of 385 lbs. The system is equally applicable to trolley cars. A. H. A.

ELECTRIC LAMPS AND LIGHTING.

2116. *Manufacture of Glow-Lamps without Caps.* **J. A. Montpellier.** (Électricien, 20. pp. 7–9, July 7, 1900.)—The author draws attention to the defects of the ordinary bayonet caps for lamps, and describes a device invented by Hollub, in which no plaster is used. The bulb of the lamp terminates in a button furnished with two small projections, upon which are mounted the contact plates, soldered to the platinum leading-in wires. A brass tubular sheath, slit at one end so as to take a springy seat on the neck of the bulb, and provided with pins to fit the bayonet socket, is buttoned on the glass projections, being held in place by a slotted plate. By this means short circuits in the cap are obviated and the process of manufacture cheapened. A. H. A.

2117. *Bremer Arc Lamp.* **W. Wedding.** (Elektrotechn. Zeitschr. 21. pp. 546–549, July 5, 1900. Paper read at the 8th annual meeting of the Verband Deutscher Elektrotechniker at Kiel.)—In this lamp the carbons are arranged horizontally, and the arc is deflected downwards by electromagnetic means. The positive carbon, in direct-current lamps, contains a compound of calcium. Photometric tests have been carried out, and the following advantages are claimed for this lamp: (1) Increased efficiency, amounting to two or three times that of ordinary arcs; (2) improved distribution of the light; (3) better colour. Details are withheld. W. H. E.

2118. *Arc Lamps on 220-volt Circuits.* **W. Mathiesen.** (Elektrotechn. Zeitschr. 21. pp. 589–591, July 12, 1900. Paper read before the Leipzig Elektrotechnische Gesellschaft.)—The paper describes the various methods adopted by the firm of Körting and Mathiesen for running 1, 2, 3, 4, 5, and 6 arc lamps in series on a 220-volt continuous current circuit. The automatic device which each lamp contains for substituting a resistance when the lamp ceases to work is explained by diagrams. For a series of three lamps the firm makes a special double lamp containing two arcs, so that six arcs are in series on the circuit. For a series of two lamps enclosed arcs are used, but it is admitted that the efficiency is not much greater than when two open arcs are run in series with a resistance. For one lamp, an enclosed arc taking 140 volts is used; the arc is about 8 mm. in length, and gives a very violet-coloured light. G. H. B.

REFERENCES.

2119. *Stansstad-Engelberg Electric Railway.* (Elect. Engin. 25. pp. 523–526, April 13, and 561–565, April 20, 1900.)—These articles comprise a detailed description of the locomotives, rack-way, generating plant, &c., of this line which is operated by multiphase currents generated by turbine-driven alternators. (See also 1899, Abstract No. 1100.) E. H. C.-H.

2120. *Electricity Supply for Small Towns.* **C. S. Vesey Brown.** (Elect. Engin. 25. pp. 878–880, June 22, 1900. Paper read before the Municipal Electrical Association.)

TELEGRAPHY AND TELEPHONY.

2121. *Munier's Multiple Telegraphs.* **Munier.** (Écl. Électr. 24. pp. 81–91, July 21, 1900.)—The inventor's first system described in 1886 and 1887 comprised a "distributor" and "compensator" for working the Hughes' type-printer in multiple. The "distributor" was a wheel divided into as many sectors as there were receivers, theoretically. Each sector contained 28 contacts connected electrically to 28 keys of a board. As the wheel revolved each sector was presented in turn to receive and re-transmit a current from the key pressed. The speed of the Hughes had to be maintained at from 120 to 140 turns, so that the inventor had to devise a method by which his transmitter would travel exactly *n* times as fast, *n* being the number of the receivers to be operated. His first thought was to provide 28 contacts in each consecutive sector of his distributor, the operator being guided by a metronome as to the right moment to press any key, and to use in the receiver a part of the type-wheel only, proportional to the number of receivers being worked, *e.g.*, the wheel would have all the characters assembled on one-fourth of the periphery if there were four receivers. However, this device would have necessitated radical alterations in existing apparatus, besides being liable to inconveniences in function as well as in effecting ordinary combinations, so that Munier employed his "compensator" in connection with the Hughes. Its mode of working and details of parts are fully described and illustrated. Its functions were to cause the printing arrangement to be affected at the right moment by the positions taken and preserved on a special ratchet wheel by a catch whose fall is actuated by an electromagnet which receives the line current, and which, as it were, registers the *moment* of arrival of that current. The type-wheel moving more slowly than the "distributor" is by means of the "compensator" enabled to print the appropriate signs during the time occupied in one revolution of the "distributor." In his model of 1887 the inventor arranged the 28 contacts of the sectors in concentric crowns instead of placing them successively upon one crown. For a quadruple transmission each contact occupied an angle of 4/112 of the periphery, and the angular space between the symmetric points of the contacts of neighbouring crowns was 1/112, the result being the same as if the contacts followed each other on the periphery and measured 1/112th.

With a view to increasing the speed of the apparatus the inventor has in his latest form abandoned the "compensator" and substituted a new arrangement which he calls a "collector," and he has modified his "distributor" by providing five divisions per sector, two for divisions of the letters of the alphabet in series and three for the letters in the series. Two brief impulses form a combination, one indicating the series, and the other for selecting the letter in that series. This result has been obtained by utilising on the one part currents of opposite signs and, on the other, a set of electromagnetic receivers designed to open and close the circuits of the "collector" containing as many divisions as a type-wheel. The "collector" is composed of two concentric crowns, the outer of which has 28 divisions corresponding to those of the Hughes type-wheel, and the other is divided into 5 parts corresponding to the 5 series of the manipulating board. Each part embraces a series and faces 6 of the divisions of the first crown, except the last part which faces 4 only. Over the two crowns travel two metallic brushes connected together. These unite successively the series to the divisions for printing the characters signalled by the armatures of the electromagnets. They are fixed on a carrier forming part of the type-wheel. E. O. W.

2122. *Long-distance Telephony over Non-Uniform Cables.* **M. I. Pupin.** (Amer. Inst. Elect. Engin., Trans. 17. pp. 245–307, April, 1900. Part II. is a reprint from Amer. Math. Soc., Trans. I.)—This paper describes and discusses a method of constructing cables and long-distance air-lines for telephony and telegraphy in which capacities and inductances are inserted at equal distances. When these distances are small in comparison with the lengths of the electric waves in use the periodically loaded line is said to behave like a uniform line, but with less distortion than when without the loads. E. H. B.

2123. *Telephone Construction.* **J. E. Stewart.** (West. Electn. 26. p. 407, June 23, 1900. Paper read before the National Telephone Association at Cleveland, June 13, 1900.)—The author describes American practice. For overhead lines he recommends 35 to 40-foot poles with 8-inch top and 42 to 43 inches circumference at 6 feet from the butt, carrying 4 to 10 insulator arms. Second growth chestnut or white cedar is best, and should be cut in winter-time when sap is down. The poles should be spaced 40 to the mile on the straight and 45 to 50 on curves, and buried 5½ feet with additional 6 inches for every 5 feet of length. Cross arms for 10 insulators 3¼ by 4¼ inches section and 10 feet long of best heart pine or fir. Bolted through arm and pole with ⅝-inch bolt, and braced with a 1¼ by ¼ by 28 wide galvanised iron. Hard-drawn copper wire No. 10 B. and S. is the best for long distances, and of course metallic circuits in all cases; and No. 14 to 18 for subscribers' circuits; a No. 14 twisted pair, rubber-covered, and braided through trees, &c., to the subscriber's place. For underground purposes, wooden or terra-cotta ducts are used. The former is creosoted under 80 lbs. pressure, and is then indestructible. A creosoted board of width equal to the duct is laid as floor; the ducts are laid with wooden joints, and another board put on top. This should be 2 feet or more below the street surface. Under terra-cotta ducts, 4 inches of concrete are first laid. When multiple, two dowel pins, ⅜ by 4 inches, should be used for each section of duct. A strip of hurlap, 6 inches wide and well soaked in asphaltum varnish, should be wrapped round the joint. The latter should then be grouted. The sides round the ducts should be filled with 3 inches of concrete and also on top. Over all a creosoted plank should be laid for the entire width to protect against accidental excavations. Ample manholes are required, 450 or 400 feet apart, with 9 to 13-inch walls, and 6 feet in depth, frame and covers resting upon the walls, covers being filled with asphaltum. All conduits or ducts should be rodded and pilot wires drawn in before completion is accepted. E. O. W.

2124. *Mildé's Telephones.* **L. Montillot.** (Électricien, 20. pp. 22–27, July 14, 1900.)—A description of wall and portable telephones, the particular features by which they differ from familiar types being the transmitters. For a wall instrument one type consists of two cylinders of carbon fixed into the two sides of a round, flat, metallic box, and separated from the metal by paper washers. The box is filled, loosely, with granules of coke. One cylinder is fixed, together with a cork washer, against the deal panel spoken to. The ends of the carbon rods which impinge upon the granules are lightly striated. The usual wires from the primary coil and battery are attached to the rods. Another form of microphone for portable purposes is designed by Steiner. Two corrugated metallic shells form the box. The upper one is corrugated horizontally, and has a cylindro-conical and striated carbon going through its centre. The lower one is conically corrugated and receives a carbon with a hollow or dished end, also striated. The space between the shells and carbons is filled with a special carbon powder, semi-conductive. The carbons are insulated from the metallic shells, and are connected as usual to the primary and battery. This microphone will function in any position, and can be used with an E.M.F. of even 8 volts without hissing. Another form of transmitter for a desk telephone is that of Kotyra. The carbon cylinders or rods are of the forms just described, but are surrounded by a band of cloth, which confines the space necessary for the granules of graphite, and makes an elastic box. This arrangement is inserted in a metallic tube, which is helically embossed and forms another elastic case. One extremity of the tube is closed by a metallic, the other by an ebonite plug. This latter is attached to the sounding-board of deal, with a cork washer intervening; one wire is fastened to the metal tube, the other penetrates the ebonite to the carbon inside. E. O. W.

2125. *Telephone-coherer.* **T. Tommasina.** (Elettricità, Milan, 19. pp. 870–874, June 16, 1900.)—The telephone-coherer is similar to an ordinary Bell telephone, except that the core is iron instead of steel. The diaphragm carries a small circular chamber of insulating material containing filings, and acting as the coherer. Two wires communicating with the filings are joined as usual to the receiving mast, a battery, a relay, and earth. The telephone coil is in the circuit closed by the relay. This arrangement gives a combined coherer and decoherer, for decoherence is produced by the movement of the diaphragm when the telephone circuit is closed by the relay, and also, when nickel and silver filings are employed, by magnetisation. When it is not required to print the signals they can be read by the sound emitted by the telephone diaphragm.

The "Telephone-auto-decoherer," or "Radio Telephone," has been designed by the author as a very simple and portable apparatus, giving sound signals only, but requiring no relay, and only one battery cell. The telephone coil is in series with one of the author's carbon self-decoherers, which is placed in a cavity in the telephone case. The telephone terminals are then connected in parallel with a battery and the receiving mast and earth. G. H. B.

REFERENCE.

2126. *Telephone Statistics.* (Journ. Télégraph. 24. pp. 150–160, July, 1900.)—A tabular statement, giving financial, technical, and general particulars about the telephone systems in the different countries of the world.